

DESCRIPTION

WATER TREATMENT SYSTEM, WATER TREATMENT METHOD, AND WATER PRODUCTION METHOD

Technical Field

[0001] The present invention relates to a water treatment system, a water treatment method, and a water production method and more particularly relates to techniques suitable for treating raw water, such as river water or groundwater, to reuse it as industrial water or the like.

Background Art

[0002] Some systems to treat raw water, such as river water or groundwater, use hollow fiber membrane filtration modules. Among them, a hollow fiber membrane filtration module disclosed in Patent Literature 1 employs a structure called "one end free", including a hollow fiber membrane bundle composed of a large number of hollow fiber membranes having one ends (the upper ends) fixed to the container and the other ends (the lower ends) that are not fixed. Because of this structure, this hollow fiber membrane filtration module has characteristics superior to those of ones including a hollow fiber membrane bundle having both ends fixed. Specifically, in the case of performing a cleaning process to remove sediment on the hollow fiber membranes by applying air scrubbing, this structure has strong effect to peel off the sediment because the not-fixed ends of the hollow fiber membranes move freely. In addition, the hollow fiber membrane filtration module in Patent Literature 1 includes a rectifier tube extending from the fixed end side of the hollow fiber membrane bundle in the longitudinal direction of the hollow fiber membrane bundle, and this rectifier tube also provides effect of preventing entanglement of the hollow fiber membranes during cleaning, cleavage of the hollow fiber membranes due to the entanglement, or breakage

of the hollow fiber membranes caused by stress concentration on the fixed end side of the hollow fiber membranes.

[0003] Meanwhile, to treat raw water having a high turbidity, adding inorganic flocculant is sometimes combined with the treatment using the hollow fiber membrane filtration module. Although it is conceivable that adding inorganic flocculant at a high concentration is effective to perform effective water treatment, the inorganic flocculant at a high concentration has a concern that the flocculant itself may cause membrane fouling and clogging, which may prevent efficient filtration treatment with the hollow fiber membranes (hereinafter simply called filtration treatment) or shorten the life of the hollow fiber membranes. For this reason, in the case where addition of inorganic flocculant is combined with filtration treatment, the concentration or amount of the inorganic flocculant added is typically kept low.

Citation List

Patent Literature

[0004]

PTL 1: Japanese Patent Publication No. 3686225

PTL 2: International Publication No. WO2013/099857

Summary of Invention

Technical Problem

[0005] However, as a result of intensive studies conducted by the inventor, it was found that a low concentration of inorganic flocculant generally makes the size of aggregates (hereinafter referred to as flocs) small, so that the flocs are more likely to clog the pores of hollow fiber membranes on the contrary, and easily enter between hollow fibers and stay there, and this reduces cleaning effect of air scrubbing.

[0006] Therefore, an object of the present invention is to improve the efficiency of filtration treatment and reduce clogging of membrane and also to improve cleaning effect when performing water treatment using a hollow fiber membrane filtration module.

Solution to Problem

[0007] In one aspect according the present invention, the present invention is a water treatment system to treat raw water with a hollow fiber membrane bundle having one end that is not fixed, which comprises:

- a turbidity measuring unit to measure turbidity of raw water before the raw water is subjected to filtration treatment with the hollow fiber membrane bundle; and

- a flocculant adding unit to add inorganic flocculant in an amount adjusted based on the measured turbidity.

[0008] In other aspect according the present invention, the present invention is a water treatment method to treat raw water with a hollow fiber membrane bundle having one end that is not fixed, which comprises:

- a turbidity measuring process to measure turbidity of raw water before the raw water is subjected to filtration treatment with the hollow fiber membrane bundle; and

- a flocculant adding process to add inorganic flocculant in an amount adjusted based on the measured turbidity.

[0009] In addition, in further aspect according the present invention, the present invention is a water production method which comprises:

- a turbidity measuring process to measure turbidity of raw water;

- a flocculant adding process to add inorganic flocculant in an amount adjusted based on the measured turbidity; and

- the raw water subjecting process to filtration treatment with the hollow fiber membrane bundle having one end that is not fixed.

Advantageous Effects of Invention

[0010] According to the present invention, before raw water is subjected to filtration treatment using a hollow fiber membrane bundle having one end that is not fixed, the turbidity of the raw water is measured, and inorganic flocculant is added in an amount adjusted based on the measured turbidity. With these processes, flocs are formed in preferred sizes, which improves the efficiency of the filtration treatment and reduces clogging of the membrane and also improves the cleaning effect.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a partially cutaway side view of an example of a hollow fiber membrane filtration module applicable to the present invention;

[Fig. 2] Fig. 2 is a block diagram schematically illustrating an embodiment of a water treatment system according the present invention, including the filtration modules illustrated in Fig. 1;

[Fig. 3] Fig. 3 is a block diagram illustrating the outline of a control system to operate the water treatment system illustrated in Fig. 2;

[Fig. 4] Fig. 4 is a flowchart illustrating an example of control procedure of the water treatment system using the control system in Fig. 3;

[Fig. 5A] Fig. 5A is a graph illustrating result of comparing water permeabilities after filtration treatment for five samples prepared by differentiating the type and concentration of inorganic flocculant added to raw water;

[Fig. 5B] Fig. 5B is a graph illustrating result of comparing water permeabilities after filtration treatment for three samples prepared by differentiating the concentration of inorganic flocculant added to raw water, relative to one of the samples in Fig. 5A;

[Fig. 6] Fig. 6 is a graph illustrating result of measuring the relationship between the concentration of inorganic flocculant added to raw water with a turbidity of 25 degrees and the water permeability;

[Fig. 7A] Fig. 7A is a graph illustrating result of comparing recoverabilities of filtration performance after cleaning for five samples prepared by differentiating the type and concentration of inorganic flocculant added to raw water;

[Fig. 7B] Fig. 7B is a graph illustrating result of comparing recoverabilities of filtration performance after cleaning for three samples prepared by differentiating the concentration of inorganic flocculant added to raw water, relative to one of the samples in Fig. 7A;

[Fig. 8] Fig. 8 is an explanatory diagram illustrating the relationship between the concentration and the SDI for the case of adding sulfate band as inorganic flocculant; and

[Fig. 9] Fig. 9 is an explanatory diagram illustrating the relationship between the turbidity of raw water and the preferred concentration of inorganic flocculant.

Description of Embodiments

[0012] Hereinafter, the present invention will be described in detail with reference to the drawings. However, the present invention is not limited to the embodiment described below.

(Definition)

[0013] Note that in this specification and the claims, raw water means river water, water from lakes, groundwater, various kinds of drained water after treatment, and the like, which mean water that can be reused as industrial water after the turbidity is removed therefrom.

[0014] Here, the turbidity is an index indicating the degree of turbidity of water specified in JIS K 0101, which is determined by comparing a sample (raw water) with

the turbidity of suspension in which 1 mg of kaolin or formazine as a standard substance is uniformly dispersed per 1 L (liter) of purified water (which is defined as a turbidity of one degree). Although in the following embodiment, kaolin is used as a standard substance and the turbidity is expressed simply as, for example, "a turbidity of 50 degrees", it goes without saying that formazine can be used as a standard substance.

[0015] In addition, examples of inorganic flocculant include aluminum based and iron based flocculants, and the following embodiment illustrates a case of using sulfate band (aluminum sulfate) and ferric chloride; however in addition to those, aluminum based materials such as polyaluminum chloride (PAC) and iron based materials such as ferric polysulfate can be used.

(Embodiment of Water Treatment System)

[0016] Fig. 1 is a partially cutaway side view of an example of a hollow fiber membrane filtration module applicable to a water treatment system according to the present invention. The hollow fiber membrane filtration module (hereinafter simply referred to as the filtration module) in Fig. 1 indicated as a whole by reference sign 100 has a container 3 housing a hollow fiber membrane bundle 1 composed of a large number of hollow fiber membranes, which can be microfiltration membranes or ultrafiltration membranes. Here, one end of each hollow fiber membrane (the lower end in Fig. 1) is sealed and is a free end which is not fixed to the container 3. On the other hand, the other end of each hollow fiber membrane (the upper end in Fig. 1) is open and is a fixed end which is fixed to the container 3 with a fixation member 6. In other words, the hollow fiber membrane bundle 1 is housed in the container 3 such that the fixed ends of the hollow fiber membranes are bundled and fixed with the fixed ends kept open, and that filtered water exits from the openings of the fixed ends.

[0017] The lower end of the container 3, in other words, the end of the container 3 on the free end side of the hollow fiber membrane bundle 1 is formed as a raw water inlet 7 for introducing raw water, to which an air inlet 9 for introducing compressed air is

connected. On the other hand, the upper end of the container 3, in other words, the end of the container 3 on the fixed end side of the hollow fiber membrane bundle 1 is formed as a treated water outlet 11 for discharging water subjected to filtration treatment (hereinafter referred to as treated water), and further, near the upper end of the container 3 is provided an air outlet 13. Note that although not illustrated, a rectifier tube can be disposed near the center of the hollow fiber membrane bundle 1 so as to extend from the fixed end side to the free end side of the hollow fiber membrane bundle 1, as described in Patent Literature 1.

[0018] Raw water is introduced into the container 3 from the raw water inlet 7 and subjected to filtration treatment by passing through the hollow fiber membrane bundle 1, and treated water flows out via the outlet 11. Meanwhile, compressed air is introduced into the container 3 via the air inlet 9 to cause movement of fluid inside the container 3, which cleans the hollow fiber membrane bundle 1 (air scrubbing, hereinafter also referred to as air backwash). As described in Patent Literature 1, if the rectifier tube is provided, the rectifier tube reduces movements of the hollow fiber membranes during air backwash, preventing entanglement of the hollow fiber membranes. Note that air introduced during the air backwash is discharged via the air outlet 13.

[0019] Fig. 2 schematically illustrates an embodiment of a water treatment system according to the present invention, including filtration modules 100 illustrated in Fig. 1. This system has multiple (four in the illustrated example) filtration modules 100, and the raw water inlets 7 and the air inlets 9 are connected to raw water piping 70 and air piping 90 in common, respectively. Raw water is supplied to the filtration modules 100 by a pump 72 via the raw water piping 70 and the raw water inlets 7, for example, at a pressure of 0.1 MPa (gauge pressure). For air backwash, compressed air at a pressure of 0.1 MPa or more is introduced from a compressed air supply source (for example, air compressor) 92 to the filtration modules 100 via the air piping 90 and the air inlets 9. Note that in this embodiment, the raw water inlets 7 are also used as

drainage outlets of the filtration modules 100, and the terminal end of the raw water piping 70 serves as drainage discharge piping 76.

[0020] The treated water outlets 11 and the air outlets 13 of the filtration modules 100 are connected to treated water piping 110 and air outlet piping 130 in common, respectively. Specifically, treated water subjected to the filtration treatment by passing through the hollow fiber membrane bundles 1 of the filtration modules 100 is lead out from the outlets 11 via the treated water piping 110 and used, for example, as industrial water. Meanwhile, the terminal end of the air outlet piping 130 is connected to the drainage discharge piping 76.

[0021] In the drainage discharge piping 76 at the terminal end of the raw water piping 70, the air piping 90, the treated water piping 110, and the air outlet piping 130 are interposed open-close valves 74, 94, 114, and 134, respectively. Each valve is controlled as appropriate, for example, during filtration treatment and during air backwash and is capable of opening or closing the flow passage of the piping. In addition, pressure gauges 78 and 118 can be arranged in the raw water piping 70 and the treated water piping 110, respectively, for example, to detect the pressure difference in raw water between at the inlet side and at the outlet side, and the results can be used, for example, to judge if the performance of the hollow fiber membranes has decreased.

[0022] Moreover, in the raw water piping 70 are arranged a turbidity measuring instrument 202 to measure turbidity before raw water is distributed to the filtration modules 100 and a flocculant adding apparatus 204 to add inorganic flocculant to the raw water based on the measured turbidity. Although these are constituents included in the features of this embodiment, any type can be used for them as appropriate. For example, an automatic turbidity measuring instrument conforming to JIS K 0801 can be used as a turbidity measuring instrument 202; however, it is preferable that the turbidity measuring instrument 202 be capable of presenting measured turbidity information to a controller described later or the like. It is also preferable that the flocculant adding

apparatus 204 include a reservoir of inorganic flocculant and an injection unit to inject the inorganic flocculant in the amount according to the instruction from the controller described later or the like, into the raw water piping 70.

(Control of the Water Treatment System)

[0023] Fig. 3 is a block diagram of a configuration example of a control system applicable to the configuration of the system illustrated in Fig. 2. The illustrated control system is configured with a controller 200 at the center, which has a CPU to execute control procedure in Fig. 4 described later, a ROM to store a program corresponding to the control procedure, and a RAM for a work area. The controller 200 controls the valves 74, 94, 114, and 134, the pump 72, the compressed air supply source (such as an air compressor) 92, and the injection unit of the flocculant adding apparatus 204, which are driven via drive units 212, 214, 216, and 218, respectively. Measurement information of the turbidity measuring instrument 202 is inputted to the controller 200, and information from a cleaning timing determination unit 220 which determines cleaning timings of air backwash or the like is also inputted to the controller 200.

[0024] The air backwash can be performed on a time basis, for example, at timings of every 15 to 30 minutes. Thus, the cleaning timing determination unit 220 may have a timer unit that manages time. However, the air backwash may be performed by judging other conditions, such as performance degradation of the hollow fiber membrane bundles 1. In this case, the cleaning timing determination unit 220 may have, for example, a comparator for comparing detection values of the pressure gauges 78 and 118. Further, the backwash may be combined with chemical cleaning in which chemicals, such as sodium hypochlorite, are injected into the filtration modules 100 as appropriate. The chemical cleaning can also be performed, for example, on a time basis, for example, at timings of every 1 to 2 days.

[0025] Fig. 4 illustrates an example of control procedure of the water treatment system in Fig. 2 using the control system in Fig. 3. When this procedure is activated, first at step S1, the valve 114 is opened and the valves 74, 94, and 134 are closed; then at step S3, driving the pump 72 is started. These operations establish the flow of raw water from the raw water piping 70 to each filtration module 100 and the flow of treated water from each filtration module 100 via the treated water piping 110 while closing the air piping 90, drainage discharge piping 76, and air outlet piping 130. Then the turbidity measuring instrument 202 measures the turbidity of the raw water at step S5, and driving the flocculant adding apparatus 204 is started at step S7 to inject inorganic flocculant in an amount appropriately determined according to the turbidity and the flow rate of the raw water to be treated. With these operations, the raw water to which the inorganic flocculant has been added flows into the filtration modules 100. In the course of this process, impurities contained in the raw water flocculate. Here, since the concentration of the inorganic flocculant is appropriately adjusted, flocs are formed in preferred sizes, which makes it less likely that the flocs clog pores in the hollow fiber membranes or stay between hollow fibers. Note that the measurement of turbidity and the adjustment of the amount of inorganic flocculant to be added according to the measurement result may be performed at appropriate timings, instead of doing it all the time.

[0026] Next, it is determined at step S11 whether it is a cleaning timing for the air backwash. If the determination is negative, the process returns to step S5. On the other hand, if the determination is affirmative; the process proceeds to step S13, the valve 114 is closed, and the valves 74, 94, and 134 are opened. These operations block the flow of raw water from the raw water piping 70 to each filtration module 100 and the flow of treated water from each filtration module 100 via the treated water piping 110, while establishing the flow passages via the air piping 90, drainage discharge piping 76, and air outlet piping 130.

[0027] At step S15, driving of the flocculant adding apparatus 204 is stopped, and at step S15, driving of the air compressor 92 is started. These operations supply compressed air to the filtration modules 100 via the air piping 90 to perform the air backwash of the hollow fiber membrane bundles 1. This air backwash transfers flocs floated inside the containers 3 and fluid containing flocs detached from the hollow fiber membrane bundles 1 through the air outlets 13 to the drainage discharge piping 76 via the air outlet piping 130. Since the raw water inlet 7 on the lower side of the container 3 also serves as the drainage outlet in this embodiment, driving the pump 72 also during the air backwash makes it possible to transfer flocs settled in the raw water inlet 7 to the drainage discharge piping 76.

[0028] The period of performing the cleaning by air backwash can also be managed on a time basis. If it is determined at step S19 that the cleaning is finished, driving of the air compressor 92 is stopped at step S21. When the process returns to step S1, the ordinary water treatment is resumed. Note that, although not illustrated in Fig. 4, a processing step for performing chemical cleaning may be added.

(As for Amount of Inorganic Flocculant to be Added)

[0029] Through various experiments described below, the inventor has studied the amount of inorganic flocculant to be added, appropriate to improve the efficiency of the filtration treatment and reduce clogging of membranes and also to improve the cleaning effects.

[0030] First, Fig. 5A is a graph illustrating an experiment result comparing water permeabilities after the filtration treatment according to the type and concentration of inorganic flocculant added to raw water. The following five samples were prepared for the experiment:

Sample 1: raw water to which no inorganic flocculant was added (a turbidity of 25 degrees)

Sample 2: raw water to which 5 ppm of sulfate band was added

Sample 3: raw water to which 10 ppm of sulfate band was added

Sample 4: raw water to which 5 ppm of ferric chloride was added

Sample 5: raw water to which 10 ppm of ferric chloride was added

Then, hollow fiber membranes of Puria (registered trademark) GS manufactured by Kuraray Aqua Corporation were cut, which is a filtration module having a structure as illustrated in Fig. 1, and a few of the hollow fiber membranes were bundled at the opposite ends from the free ends such that the total area was 0.0152 m². The obtained bundle of the hollow fiber membranes was used as filtration membranes for testing. Raw water was supplied to the filtration membranes at a pressure of 0.1 MPa.

[0031] The vertical axis of Fig. 5A represents the flow rate of treated water, which indicates how many L (litters) of treated water was obtained per 1 m² of membrane, per hour. From this graph, it was found that adding inorganic flocculant to raw water provides better water permeability and makes possible an efficient filtration treatment without clogging of the membranes, and that the higher the addition rate of inorganic flocculant (concentration) is, the more efficient the filtration treatment is. Then, it is thought that this is because flocs were formed in preferred sizes.

[0032] Then, the inventor selected sulfate band as inorganic flocculant and prepared the following samples in addition to sample 3 to study water permeability in the same manner:

Sample 3-2: raw water to which 15 ppm of sulfate band was added

Sample 3-3: raw water to which 25 mm of sulfate band was added

Fig. 5B is a graph illustrating the experiment result. From this graph, it was found that Sample 3-2, which has a higher addition rate (concentration) of inorganic flocculant than Sample 3, has a higher water permeability than Sample 3, but that Sample 3-3, in which inorganic flocculant was added at a still higher concentration, has a lower water permeability, on the contrary.

[0033] The inventor further conducted an experiment to study water permeability, changing the rate of sulfate band added to raw water (a turbidity of 25 degrees). The raw water used in this experiment had a water quality within the following range:

pH: 5.4 to 7.8

SS: 20 to 380 mg/L

Color: 30 to 50

Electrical conductivity: 1.80 to 5.34 mS/cm

Salinity: 0.3%

Ca: 250 to 870 mg/L

SiO₂ : 7 mg/L

NH₄⁺: 0.2 to 0.7 mg/L

CaCO₃: 150 to 200 mg/L

[0034] Fig. 6 is a graph illustrating the experiment result. From this result, the following was confirmed: It is preferable to add inorganic flocculant such that the concentration of inorganic flocculant is appropriate. Specifically, in the case of using sulfate band, it is preferable to add sulfate band to raw water such that the concentration is around 15 ppm, to provide favorable water permeability.

[0035] The inventor also conducted an experiment to check the cleaning effect depending on the concentration of inorganic flocculant. In the experiment, first, after 50 L of each of the above Samples 1 to 5 was supplied to the same filtration module described above, physical cleaning (air backwash) and (chemical cleaning) were performed.

[0036] Fig. 7A is a graph showing how much the membrane performance was recovered after cleaning by using the ratio of the flow rate with the water permeability before the supply being taken as 100. From this graph, it was found that adding inorganic flocculant to raw water generally provides better recoverability and that with the water permeability illustrated in Fig. 5A taken into account, it is preferable to add

inorganic flocculant such that the concentration is higher than or equal to 10 ppm. It is thought that this is also because flocs were formed in preferred sizes.

[0037] Then, the inventor selected sulfate band as inorganic flocculant and prepared Samples 3, 3-2, and 3-3 to study the recoverability in the same manner. Fig. 7B is a graph illustrating the experiment result. From this graph, it was found that in the case of using sulfate band, it is preferable to add sulfate band to raw water having a turbidity of 25 degrees such that the concentration is around 15 ppm (for example, within a range of 12.5 to 17.5 ppm), also from the viewpoint of the recoverability after cleaning. It is particularly preferable to use inorganic flocculant at a concentration described above in the present invention in the treatment of raw water having the above water quality.

[0038] The inventor further conducted an experiment to evaluate the slit density index (SDI) of raw water to which sulfate band was added in accordance with the provisions in ASTM D 4189 of the United States, following the method described in the specification of Patent Literature 2.

[0039] Fig. 8 illustrates the result. While water generally needs to be treated such that the SDI thereof is lower than or equal to 3 to 4, it was found that the water to which sulfate band was added shows better SDIs than the water subjected to UF (ultrafiltration membrane) treatment which are indicated by "×".

[0040] In addition, the inventor conducted an experiment to determine the concentration of inorganic flocculant (sulfate band) preferable for various turbidities from the viewpoints of water permeability and recoverability after cleaning.

[0041] Fig. 9 illustrates the result, from which it was found that there is an almost linear relationship between the turbidity and the preferred addition amount of inorganic flocculant. In the case of Fig. 9, the relationship is approximately expressed by the following formula:

$$\text{the addition amount of inorganic flocculant (ppm)} = 0.45 \times \text{turbidity} + 5.$$

Thus, to apply this to the water treatment system illustrated in Figs. 2 and 3, the flocculant adding apparatus 204 needs to be controlled at step S7 in Fig. 4 such that inorganic flocculant is added in the amount with which the concentration according to the flow rate of raw water to be treated is obtained, based on the turbidity measured by the turbidity measuring instrument 202. Note that to add a preferred amount of inorganic flocculant, for example, a table including the turbidity, addition amount, and flow rate of raw water may be stored in advance in a ROM of the controller 200 or the like, so that the table can be referred to. Alternatively, the CPU of the controller 200 may calculate the preferred concentration and, further, the addition amount based on the turbidity using the above formula.

(Others)

[0042] Note that the present invention is not limited to the above embodiment and the modification examples described above. For example, although description has been specifically provided for the preferred concentration for the case where sulfate band is added as inorganic flocculant, this is a mere example. It goes without saying that also in the case of using PAC, or ferric chloride or ferric polysulfate, which is iron based inorganic flocculant, it is possible to determine the appropriate addition amount in the same manner. It also goes without saying that it is possible to determine the type and concentration of inorganic flocculant to be used as well as the addition amount according to the specifications of the hollow fiber membrane (such as the diameter of the hollow fibers and the diameter of the pores) or according to the conditions for use of the filtration system and the environmental conditions (such as water temperature).

[0043] In addition in the above embodiment, a water treatment system that automatically measures turbidity and adds inorganic flocculant has been illustrated as an example; however, at least part of the operation may be performed according to instructions or operations by the operator, in light of the gist of the present invention embodied in a water treatment method or a water production method. In addition,

water subjected to the treatment according to the present invention may be directly used as industrial water or the like or may be subjected to an additional treatment.

CLAIMS

1. A water treatment system to treat raw water with a hollow fiber membrane bundle having one end that is not fixed, characterized in that the water treatment system comprises:

a turbidity measuring unit to measure turbidity of raw water before the raw water is subjected to filtration treatment with the hollow fiber membrane bundle; and

a flocculant adding unit to add inorganic flocculant in an amount adjusted based on the measured turbidity.

2. The water treatment system according to claim 1, characterized in that when the turbidity measured by the turbidity measuring unit is X degrees (kaolin), the flocculant adding unit adds the inorganic flocculant such that concentration becomes Y (ppm) determined by the following formula:

$$Y = 0.45 \times X + 5.$$

3. The water treatment system according to claim 1 or 2, characterized in that the hollow fiber membrane bundle is microfiltration membrane or ultrafiltration membrane.

4. The water treatment system according to any one of claims 1 to 3, characterized in that aluminum sulfate is used as the inorganic flocculant.

5. The water treatment system according to any one of claims 1 to 4, characterized in that

cleaning of the hollow fiber membrane bundle is performed by introducing compressed air at a pressure of 0.1 MPa or more.

6. A water treatment method to treat raw water with a hollow fiber membrane bundle having one end that is not fixed, characterized in that the water treatment method comprises:

a turbidity measuring process to measure turbidity of raw water before the raw water is subjected to filtration treatment with the hollow fiber membrane bundle; and

a flocculant adding process to add inorganic flocculant in an amount adjusted based on the measured turbidity.

7. A water production method comprises:

a turbidity measuring process to measure turbidity of raw water;

a flocculant adding process to add inorganic flocculant in an amount adjusted based on the measured turbidity; and

the raw water subjecting process to filtration treatment with the hollow fiber membrane bundle having one end that is not fixed.