

DESCRIPTION

WATER TREATMENT APPARATUS AND WATER TREATMENT METHOD

TECHNICAL FIELD

5 [0001] The present disclosure relates to a water treatment apparatus and a water treatment method.

BACKGROUND ART

[0002] One of general methods for treating urban sewage,
10 organic waste water, and nitrogen-containing waste water is an activated sludge process. The activated sludge process is a method in which microorganisms (activated sludge) having a purification function are stored in a biological reaction tank and then are mixed and contacted with the waste water
15 while being aerated, whereby contaminants in the waste water are oxidized and decomposed. In order to sufficiently clean out the contaminants, it is necessary to supply an appropriate amount of air to the biological reaction tank.

[0003] In addition, for disinfection, sterilization,
20 deodorization, and the like of secondary treated water treated through the activated sludge process as described above and water that has undergone flocculation sedimentation or rapid sand filtration in water treatment, ozone gas is supplied to treatment target water, thereby performing
25 treatment of oxidizing and decomposing contaminants such as

organic substances and viruses in the water. Also here, in order to sufficiently clean out the contaminants, it is necessary to supply an appropriate amount of ozone gas to the treatment target water.

5 [0004] Further, as a method for treating phosphorus-containing waste water, there is a flocculation sedimentation method. In this method, a flocculant is reacted with phosphoric acid in treatment target water, whereby phosphorus is settled as a metal salt or a calcium salt and thus
10 phosphorus is cleaned out from the water. The supply amount of the flocculant varies in accordance with the concentration of phosphorus contained in the treatment target water. Therefore, it is necessary to supply an appropriate amount of the flocculant to the treatment target water.

15 [0005] All of the water treatment methods shown above are the same in that the treatment target water is purified by supplying a treatment agent such as air, ozone gas, or a flocculant to a water treatment tank into which the treatment target water flows, and therefore it is necessary to
20 immediately control the supply amount of the treatment agent in response to variation in a load value. For example, Patent Document 1 discloses that, in a water treatment system using activated sludge, a setting value for the nitrification rate in an aerobic tank is determined from an organic
25 substance concentration and a nitrogen concentration in raw

water, and on the basis of an ammonia nitrogen concentration and a nitrate nitrogen concentration in the aerobic tank, a calculated value of the nitrification rate in the aerobic tank is compared with the setting value of the nitrification rate, thereby performing aeration control.

[0006] In addition, for example, Patent Document 2 discloses that, in water treatment equipment using ozone, an ozone generator and an ozone dissolver are incorporated into an ozone aeration tank, all the generated ozone is dissolved into treatment target water, and ozone treatment is performed, thus reducing construction cost and operation cost for the ozone generator.

[0007] In addition, for example, Patent Document 3 discloses that, in a water treatment system, an aeration amount and a flocculant injection amount for a biological treatment tank are controlled on the basis of the flow rate and the phosphorus component concentration of treatment target water, and the phosphorus component concentration of flow-out water.

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CITATION LIST

PATENT DOCUMENT

[0008] Patent Document 1: Japanese Laid-Open Patent Publication No. 2014-184396

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Patent Document 2: Japanese Laid-Open Patent

Publication No. 2011-5406

Patent Document 3: Japanese Laid-Open Patent

Publication No. 2010-269276

5 SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0009] For example, in Patent Document 1, aeration control is performed on the basis of the present values of the organic substance concentration and the nitrogen
10 concentration of flow-in water. However, it takes time for activated sludge to increase in its purification function through aeration, and therefore, the control based on the present value of the flow-in water quality might cause water quality deterioration due to insufficiency of the aeration
15 amount in a case of high load. In addition, in a case of low load, a necessary aeration amount is reduced, but control for the aeration amount does not catch up with reduction of the load value, and thus energy loss might occur due to excessive aeration.

20 [0010] In Patent Document 2, the output of the ozone generator is changed in response to variation in the load value at the present. Therefore, in a case of high load, the flow-out water quality might be deteriorated due to insufficiency of the supply amount of ozone gas, and in a
25 case of low load, energy loss might occur due to excess

supply of ozone gas.

[0011] In Patent Document 3, the flocculant is supplied in response to variations in the flow rate and the phosphorus component concentration of flow-in water at the present, as
5 in Patent Document 1. Therefore, in a case where the load value is increased, water quality might be deteriorated due to insufficiency of supply of the flocculant, and in a case of low load, cost might increase due to excessive supply of the flocculant.

10 [0012] As described above, in any of the conventional technologies, in a case of using control of supplying a treatment agent in response to variation in the load value at the present, the supply amount of the treatment agent is increased or decreased after the variation in the load value
15 is detected. Therefore, there is a problem that, in a case of high load, the flow-out water quality might be deteriorated due to insufficiency of the supply amount of the treatment agent, and in a case of low load, cost might increase due to excessive supply of the treatment agent.

20 [0013] The present disclosure has been made to solve the above problem, and an object of the present disclosure is to provide a water treatment apparatus and a water treatment method that can suppress variation in the water quality of treated water obtained through water treatment on treatment
25 target water and reduce operation cost.

SOLUTION TO THE PROBLEMS

[0014] A water treatment apparatus according to the present disclosure is a water treatment apparatus for performing water treatment by supplying a treatment agent to treatment target water flowing into a water treatment tank, the water treatment apparatus including: a load measurement unit which measures, as a first load value, a load value of the treatment target water flowing into the water treatment tank at a first time point; a prediction unit which predicts, as a second load value, a load value of the treatment target water flowing into the water treatment tank at a second time point after the first time point, on the basis of the first load value measured by the load measurement unit; and a supply unit which supplies the treatment agent in a supply amount corresponding to the second load value predicted by the prediction unit, to the treatment target water in the water treatment tank, at a third time point between the first time point and the second time point.

A water treatment method according to the present disclosure is a water treatment method for performing water treatment by supplying a treatment agent to treatment target water, the water treatment method including: a first step of measuring, as a first load value, a load value of the treatment target water at a first time point; a second step

of predicting, as a second load value, a load value of the treatment target water at a second time point after the first time point, on the basis of the first load value measured in the first step; and a third step of supplying the treatment agent in a supply amount corresponding to the second load value predicted in the second step, to the treatment target water, at a third time point between the first time point and the second time point.

10 EFFECT OF THE INVENTION

[0015] The water treatment apparatus and the water treatment method according to the present disclosure can suppress variation in the water quality of treated water obtained through water treatment on treatment target water and reduce operation cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] [FIG. 1] FIG. 1 is a diagram showing the configuration of a water treatment apparatus according to embodiment 1.

[FIG. 2] FIG. 2 is a flowchart showing a water treatment method in the water treatment apparatus shown in FIG. 1.

[FIG. 3] FIG. 3 is a graph showing temporal changes in a load value and an aeration amount in the water

treatment apparatus according to embodiment 1 and in a comparative example.

[FIG. 4] FIG. 4 is a graph showing temporal changes in the ammonia nitrogen concentration of treated water in the water treatment apparatus according to embodiment 1.

[FIG. 5] FIG. 5 is a graph showing temporal changes in a load value and an aeration amount in the water treatment apparatus according to embodiment 1 and in a comparative example.

[FIG. 6] FIG. 6 is a graph showing temporal changes in the ammonia nitrogen concentration of treated water in the water treatment apparatus according to embodiment 1.

[FIG. 7] FIG. 7 is a diagram showing the configuration of a water treatment apparatus according to embodiment 2.

[FIG. 8] FIG. 8 is a diagram showing the configuration of a water treatment apparatus according to embodiment 3.

[FIG. 9] FIG. 9 is a diagram showing the configuration of a water treatment apparatus according to embodiment 4.

[0017] The present disclosure relates to a water treatment apparatus and a water treatment method for performing water treatment through purification treatment for contaminants contained in treatment target water such as urban sewage, organic waste water, nitrogen-containing waste water, sewage secondary treated water, or phosphorus-containing waste water.

[0018] Embodiment 1

FIG. 1 is a diagram showing the configuration of a water treatment apparatus according to embodiment 1. In FIG. 1, the water treatment apparatus includes: a water treatment tank 1; a first calculation unit 91, a first supply unit 41, and a first aeration unit 31, a second calculation unit 92, a second supply unit 42, and a second aeration unit 32, and a third calculation unit 93, a third supply unit 43, and a third aeration unit 33, as supply units; a load measurement unit 5; a recording unit 6; a prediction unit 7; and a sedimentation tank 2. The first calculation unit 91, the first supply unit 41, and the first aeration unit 31 form one supply unit.

[0019] In addition, the second calculation unit 92, the second supply unit 42, and the second aeration unit 32 form one supply unit. In addition, the third calculation unit 93, the third supply unit 43, and the third aeration unit 33 form one supply unit. In the present embodiment, three supply

units are provided as an example. However, depending on the size of the water treatment tank 1, the treatment amount for treatment target water, and the like, a case of providing one supply unit, a case of providing two supply units, and a case of providing four or more supply units, are also conceivable. The number of the supply units is the same also in the subsequent embodiments, and the description thereof is omitted as appropriate.

[0020] Treatment target water flows from the outside into the water treatment tank 1 via a pipe 101. In the water treatment tank 1, activated sludge is stored and purification treatment is performed on the treatment target water through biological reaction with the activated sludge. The treatment target water treated in the water treatment tank 1 (hereinafter, the treatment target water treated in the water treatment tank 1 is referred to as "treated water") is discharged to the sedimentation tank 2 via a pipe 102. In the sedimentation tank 2, activated sludge contained in the treated water discharged from the water treatment tank 1 via the pipe 102 is settled. The supernatant water after the sedimentation treatment in the sedimentation tank 2 is discharged via a pipe 103. In addition, the activated sludge separated through the sedimentation treatment in the sedimentation tank 2 is returned to the water treatment tank 1 via a pipe 104. Meanwhile, excess activated sludge in the

sedimentation tank 2 is discharged to the outside via a pipe 105.

[0021] The aeration units 31 to 33 are provided so as to be arranged in the direction in which the treatment target water flows downstream in the water treatment tank 1. The aeration units 31 to 33 supply treatment agents in a gas state sent via pipes 411, 421, 431 from the supply units 41 to 43, into the water treatment tank 1.

[0022] The load measurement unit 5 is mounted to the pipe 101 and measures a load value of the treatment target water flowing into the water treatment tank 1. The recording unit 6 receives the load value measured by the load measurement unit 5 via a signal line 51, and records the load value together with a time. The prediction unit 7 receives a past load value and a time of the load value recorded in the recording unit 6, via a signal line 61, and further receives a first load value of treatment target water at the present as a first time point measured by the load measurement unit 5, and the time thereof, via a signal line 52 from the load measurement unit 5. Then, the prediction unit 7 predicts, as a second load value, a load value of treatment target water that flows into the water treatment tank 1 at a second time point after the present (first time point).

[0023] The calculation units 91 to 93 receive the second load value of treatment target water predicted by the

prediction unit 7 via a signal line 71, and calculate the supply amounts of the treatment agents corresponding to the second load value. In the present embodiment 1, air is used as the treatment agents, and therefore the supply amounts may
5 be referred to as aeration amounts. Then, the calculation units 91 to 93 cause the supply units 41 to 43 to supply, to the respective aeration units 31 to 33, the treatment agents in the supply amounts calculated correspondingly for the second load value of the treatment target water, at a third
10 time point between the first time point and the second time point.

[0024] At this time, the supply amounts of the treatment agents calculated by the calculation units 91 to 93 are sent to the supply units 41 to 43 via signal lines 911, 921, 931.
15 In addition, the treatment agents supplied from the supply units 41 to 43 are supplied to the aeration units 31 to 33, and the treatment agents are supplied into the water treatment tank 1. Thus, the water treatment apparatus of the present embodiment 1 is configured such that, in the water
20 treatment tank 1, the treatment target water flowing in via the pipe 101 is mixed and stirred with the activated sludge while being aerated by the aeration units 31 to 33 with air which is the treatment agents supplied from the supply units 41 to 43, so that contaminants in the water are biologically
25 oxidized and decomposed, whereby purification treatment is

performed.

[0025] Next, a specific example and the details of each part will be described. First, a specific example of the load measurement unit 5 will be described. The load measurement unit 5 measures a load value of treatment target water flowing into the water treatment tank 1, and, specifically, includes at least one measurement device of a flowmeter or a contaminant concentration meter (an ammonia nitrogen concentration meter, a total nitrogen concentration meter, a biochemical oxygen demand (BOD) meter, a chemical oxygen demand (COD) meter, etc.) for the treatment target water. The load measurement unit 5 measures the load value continuously or intermittently at predetermined time intervals. All the load values are associated with times at which the load values are measured.

[0026] The load measurement unit 5 may include both of the flowmeter and the contaminant concentration meter described above. In this case, the product of the flow rate and the contaminant concentration of the treatment target water flowing into the water treatment tank 1 may be calculated as the load value. Thus, the load measurement unit 5 measures the load value of the treatment target water substantially flowing into the water treatment tank 1. As an alternative for the flowmeter, the opening degree of a weir of an inflow ditch may be used instead of the flow rate. Further, for

considering the influence of the temperature depending on the seasons or the like, a water temperature meter may be provided in addition to the flowmeter and the contaminant concentration meter. Here, a case of not providing a water temperature meter will be described.

[0027] In FIG. 1, an example in which the load measurement unit 5 is connected to the pipe 101 is shown. However, the load measurement unit 5 may be provided on the upstream side in the water treatment tank 1. Thus, it is possible to consider the load value including the influence of activated sludge returned via the pipe 104. Further, the influence of a time lag until actually flowing into the water treatment tank 1 after passing through the pipe 101 can be eliminated, whereby more accurate control can be performed. This also applies in the subsequent embodiments, and the description thereof is omitted as appropriate.

[0028] Next, a specific example of the prediction unit 7 will be described. The prediction unit 7 predicts the second load value of treatment target water for a predetermined period later (second time point), on the basis of a past load value and the first load value at the present (first time point) measured by the load measurement unit 5. Regarding the predetermined period later (second time point) for which the prediction unit 7 performs prediction, an optimum value thereof differs in accordance with a load variation pattern

of the treatment target water flowing into the water treatment apparatus. It is generally known that, in a case of urban sewage in sunny weather, or the like, the load value varies periodically. Therefore, it is desirable that the predetermined period is set within a range not exceeding the cycle of the load value, and the prediction is performed for approximately thirty minutes to six hours later. Such prediction makes it possible to operate the water treatment apparatus in prospect of variation in the load value.

10 [0029] In the prediction for the second load value of treatment target water at the second time point by the prediction unit 7, the second load value of treatment target water for the predetermined period later as the second time point after the first time point is predicted from the first load value of treatment target water at the present which is the first time point, on the basis of data of the past load values accumulated. Specific examples of the prediction method include a neural network, deep learning, reinforcement learning, machine learning, and local approximation. As data for learning, data of the past load values recorded in the recording unit 6 is used. The load value may be predicted in association with water quality data other than load value data, or data that can be acquired from the outside.

[0030] For example, in water treatment by the activated sludge process, it is general that the aeration amount to be

supplied to the water treatment tank 1 is also increased or decreased along with increase or decrease of the load value. Therefore, if data of the past load values and time-series data of the past aeration amounts are learned in association
5 with each other, it becomes possible to accurately predict load value variation that requires great increase or decrease of the aeration amount among load value variation patterns. In addition, if data of the past load values and time-series data of a rain cloud radar or a rainfall amount are learned
10 in association with each other, it becomes possible to accurately predict variation in the inflow amount of treatment target water or the water quality of treatment target water due to rainfall.

[0031] Next, a specific example of the calculation units
15 91 to 93 will be described. The calculation units 91 to 93 have calculation formulas for calculating the aeration amounts of the treatment agents to be supplied from the aeration units 31 to 33 at the third time point between the first time point and the second time point, using the first
20 load value of treatment target water at the present as the first time point, measured by the load measurement unit 5, or the second load value of treatment target water for the predetermined period later as the second time point after the first time point, predicted by the prediction unit 7.

25 [0032] Specifically, the calculation units 91 to 93 have

coefficients set in advance for the aeration units 31 to 33 respectively connected thereto, and each calculate the sum of the following (A) and (B).

(A) A supply amount obtained by multiplying the
 5 load value of treatment target water flowing into the water treatment tank 1 measured by the load measurement unit 5, by the coefficient set in advance for each aeration unit 31 to 33

(B) Constant

10 The above coefficients are values set in advance so as to obtain, through the above calculation, optimum aeration amounts for the aeration amounts to quickly follow variation in the load value flowing into the water treatment tank 1, and these values can be set in accordance with the positions
 15 or the number of the aeration units 31 to 33.

[0033] For example, in a case where the load measurement unit 5 is provided with the flowmeter and the ammonia nitrogen concentration meter as the contaminant concentration meter, the first calculation unit 91 calculates a setting
 20 value G1 [Nm³/hr] for the aeration amount to be supplied from the first aeration unit 31, by the following Expression (1).

$$G1 = k11 \cdot \text{SIN},N \cdot QIN + k13 \quad \dots (1)$$

SIN,N: the ammonia nitrogen concentration [mg/L] of treatment target water flowing into the water treatment tank

QIN: the flow rate [m³/hr] of treatment target
water flowing into the water treatment tank 1

k11, k13: constant

[0034] Similarly as in the above case, the calculation

5 units 92, 93 calculate setting values G2, G3 [Nm³/hr] for the
aeration amounts to be supplied from the aeration units 32,
33, by the following Expressions (2), (3), respectively.

$$G2 = k21 \cdot \text{SIN}, N \cdot \text{QIN} + k23 \quad \dots (2)$$

k21, k23: constant

10 $G3 = k31 \cdot \text{SIN}, N \cdot \text{QIN} + k33 \quad \dots (3)$

k31, k33: constant

[0035] In the above Expressions (1) to (3), the
coefficients k11, k21, k31 set in advance correspondingly for
the aeration units 31 to 33 are values set in advance so as
15 to obtain, through the above calculation, optimum aeration
amounts for the aeration amounts to quickly follow variation
in the load value for flowing into the water treatment tank
1, as described above. The coefficients k11, k21, k31 are
not necessarily all equal to each other, and may be set to
20 different values in accordance with the positions of the
aeration units 31 to 33. In addition, even after the
coefficients k11, k21, k31 are set once, it is possible to
set optimum values again as appropriate in accordance with
season change, change of a target water quality of the
25 treated water, and the like.

[0036] As described above, the calculation units 91 to 93 calculate the aeration amounts to be supplied from the aeration units 31 to 33 at the third time point between the first time point and the second time point, on the basis of the aeration amount calculation formulas provided in the calculation units 91 to 93 and the second load value of treatment target water at the second time point predicted by the prediction unit 7. In the aeration amount calculation formulas provided in the calculation units 91 to 93, the first load value at the present (first time point) is denoted by "SIN,N, QIN". With respect to this, the above calculation formulas are for calculating optimum aeration amounts. However, in the calculation units 91 to 93, the second load value "S'IN,N, Q'IN" of treatment target water at the second time point, instead of the first load value "SIN,N, QIN" of treatment target water at the present, is inputted in the above calculation formulas, thereby calculating the aeration amounts corresponding to the second load value of treatment target water.

[0037] Specific description will be given on the basis of Expressions (1) to (3) shown above. In Expressions (1) to (3) shown above, the first load value "SIN,N, QIN" of treatment target water at the present is inputted, whereby optimum aeration amounts for the first load value at the present are calculated. However, in the calculation units 91

to 93, the second load value "S'IN,N, Q'IN" of treatment target water predicted for the second time point is inputted, to calculate target aeration amounts (at the third time point) for the respective aeration units 31 to 33.

5 [0038] The setting values G1 to G3 for the aeration amounts at the third time point calculated as described above are respectively transmitted to the supply units 41 to 43 via the signal lines 911 to 931. The supply units 41 to 43 supply air in the aeration amounts set respectively, via the
10 pipes 411 to 431 and the aeration units 31 to 33, into the water treatment tank 1.

[0039] As described above, after the first load value of treatment target water at the present is measured by the load measurement unit 5, the second load value of treatment target
15 water for the predetermined period later is calculated by the prediction unit 7, the supply amounts of the treatment agents at the third time point are calculated by the calculation units 91 to 93, the aeration amounts are controlled in the supply units 41 to 43, and air is moved through the pipes 411
20 to 431, whereby the target aeration amounts are supplied from the aeration units 31 to 33 to the water treatment tank 1.

At this time, until the aeration amounts at the third time point calculated by the calculation units 91 to 93 are actually supplied from the aeration units 31 to 33 after the
25 first load value of treatment target water at the present is

measured by the load measurement unit 5, there is a time lag including a calculation time for the second load value of treatment target water, a calculation time for the aeration amount at the third time point, a control time for the
5 aeration units 31 to 33, a movement time of air in the pipes, and the like. Therefore, it is necessary to set the predetermined period used for prediction of the second load value of treatment target water in the prediction unit 7 so that the time lag becomes shorter than the predetermined
10 period. Thus, the aeration amounts can be controlled in advance before the load value actually reaches the predicted value.

[0040] Next, a water treatment method for the water treatment apparatus of embodiment 1 configured as described
15 above will be described with reference to FIG. 2. First, treatment target water flows into the water treatment tank 1 via the pipe 101. At this time, the load measurement unit 5 measures the first load value of the treatment target water at the present (first time point) (step ST1 in FIG. 2). In
20 addition, the first load value is recorded in the recording unit 6 together with the measurement time thereof (step ST5 in FIG. 2). Next, the prediction unit 7 predicts the second load value of the treatment target water at the second time point after the present (first time point), using the first
25 load value measured by the load measurement unit 5, the past

load value recorded in the recording unit 6, and the like
(step ST2 in FIG. 2). Next, the calculation units 91 to 93
calculate the supply amounts of the treatment agents on the
basis of the second load value of the treatment target water
5 (step ST3 in FIG. 2). Next, the calculation units 91 to 93
supply the treatment agents in the above-calculated supply
amounts, to the water treatment tank 1 via the supply units
41 to 43 and the aeration units 31 to 33, at the third time
point between the first time point and the second time point
10 (step ST4 in FIG. 2).

[0041] Next, the effects of the water treatment method of
embodiment 1 performed as described above will be described
with reference to FIG. 3 to FIG. 6. FIG. 3 and FIG. 4 show a
case where, at a predetermined period later from the present,
15 the second load value of the treatment target water is
predicted to become greater than the first load value of the
treatment target water at the present. FIG. 5 and FIG. 6
show a case where, at the predetermined period later from the
present, the second load value of the treatment target water
20 is predicted to become smaller than the first load value of
the treatment target water at the present. FIG. 3 and FIG. 5
are graphs showing temporal changes in the aeration amount
and the load value. FIG. 4 and FIG. 6 are graphs showing
temporal changes in the ammonia nitrogen concentration of the
25 treated water that has flowed out, i.e., the treated water

that has undergone the water treatment in the water treatment tank 1.

[0042] In FIG. 3 to FIG. 6, T1 denotes the present and is defined as the first time point. T2 is the second time point
5 T2 which is the predetermined period later from the first time point T1. In addition, T3 is the third time point between the first time point T1 and the second time point T2. In FIG. 3, F1 is a graph indicating the actual value of the load value. F2 is a graph indicating the predicted value of
10 the load value. D1 is a graph indicating the aeration amount based on the load value F1. D2 is a graph indicating the aeration amount based on the load value F2. In FIG. 4, N1 is a graph indicating the ammonia nitrogen concentration (hereinafter, referred to as "ammonia nitrogen concentration
15 of treated water") of the treated water having undergone the water treatment in the water treatment tank 1 and discharged from the water treatment tank 1, in a case of performing the treatment using the aeration amount D1. N2 is a graph indicating the ammonia nitrogen concentration of the treated
20 water in a case of performing the treatment using the aeration amount D2.

[0043] In FIG. 5, F3 is a graph indicating the actual value of the load value. F4 is a graph indicating the predicted value of the load value. D3 is a graph indicating
25 the aeration amount based on the load value F3. D4 is a

graph indicating the aeration amount based on the load value F4. In FIG. 6, N3 is a graph indicating the ammonia nitrogen concentration of the treated water in a case of performing the treatment using the aeration amount D3. N4 is a graph indicating the ammonia nitrogen concentration of the treated water in a case of performing the treatment using the aeration amount D4.

[0044] First, in a comparative example, as shown in FIG. 3, in a case of using the load value F1 "SIN,N, QIN" at the present for calculation of the aeration amount, the aeration amount D1 is increased at the same timing T0 as increase in the load value F1. However, it takes time for the activated sludge to increase in its purification function through aeration. Therefore, in particular, in a case where the load value F1 sharply increases, increase in the purification function of the activated sludge due to increase in the aeration amount D1 does not catch up, so that the ammonia nitrogen concentration N1 of the treated water might exceed SOUT,cont which is an upper limit value for management, as shown in FIG. 4.

[0045] On the other hand, in the present disclosure, in a case where the second load value of the treatment target water at the second time point T2 which is the predetermined period later from the first time point T1 at the present is predicted to become greater than the first load value at the

present, the predicted second load value " $S'_{IN,N}$, Q'_{IN} " of the treatment target water is inputted in the above Expressions (1) to (3). Thus, at the stage when the load value F_2 is predicted to increase, values greater than the present values of the ammonia nitrogen concentration and the flow rate of the treatment target water are inputted as the load value in the above Expressions (1) to (3). As a result, the aeration amount D_2 can be increased from the third time point T_3 which is before the load value actually increases.

Thus, the aeration amount is increased in advance in prospect of increase in the load value, and the treatment target water with high load flows into the water treatment tank 1 in a state in which the purification function of the activated sludge has increased sufficiently. In this way, as shown in FIG. 4, increase in the ammonia nitrogen concentration N_2 of the treated water due to increase in the load value can be suppressed to the minimum level, and even in a case where the load value sharply increases, the ammonia nitrogen concentration N_2 of the treated water can be reduced to $S_{OUT,cont}$ or smaller.

[0046] In addition, in a comparative example, as shown in FIG. 5, in a case of using the load value " $S_{IN,N}$, Q_{IN} " at the present for calculation of the aeration amount, the aeration amount D_3 is decreased at the same timing T_0 as decrease in the load value F_3 . However, in particular, in a case where

the load value F3 sharply decreases, control for the aeration amount D3 is delayed relative to decrease in the load value F3, so that an excessive aeration amount D3 might be supplied.

5 [0047] On the other hand, in the present disclosure, in a case where the second load value of the treatment target water at the second time point T2 which is the predetermined period later from the first time point T1 at the present is predicted to become smaller than the first load value at the present, the predicted second load value "S'IN,N, Q'IN" of
10 the treatment target water is inputted in the Expressions (1) to (3) shown above. Thus, at the stage when the load value F4 is predicted to decrease, values smaller than the present values of the ammonia nitrogen concentration and the flow
15 rate of the treatment target water are inputted as the load value in the above Expressions (1) to (3). As a result, the aeration amount D4 can be decreased from the third time point T3 which is before the load value actually decreases. Thus, the aeration amount is decreased in advance in prospect of
20 decrease in the load value, and accordingly, the ammonia nitrogen concentration N4 of the treated water temporarily increases, but thereafter, the treatment target water with a decreased load value actually flows into the water treatment tank 1. Therefore, the ammonia nitrogen concentration N4 of
25 the treated water does not exceed SOUT,cont which is the

upper limit value for management, and in a state in which the water quality of the treated water is kept preferable, it is possible to suppress excessive aeration, i.e., an aeration amount M indicated by a hatched area representing the

5 difference between the aeration amount D3 and the aeration amount D4 in FIG. 5.

[0048] As described above, the load value of the treatment target water flowing into the water treatment tank 1 is predicted, and the air amount supplied into the water
10 treatment tank 1 is set on the basis of the predicted load value. Therefore, in a case where the load value increases, the aeration amount is increased in advance, whereby deterioration in the water quality of the treated water can be suppressed. In addition, in a case where the load value
15 decreases, the aeration amount is decreased in advance, whereby excessive aeration can be suppressed while the water quality of the treated water is kept below the upper limit value for management.

[0049] Alternatively, there is a case where the water
20 quality of the treated water that flows out is desired to be kept as preferable as possible relative to the above-described case. In the above method, in a case where the predicted load value decreases, decreasing the aeration amount in advance temporarily deteriorates the water quality
25 of the treated water. Therefore, in order to prevent this,

control is performed such that the predicted load value
 "S'IN,N, Q'IN" is inputted only in a case where the predicted
 load value increases, and the load value "SIN,N, QIN" at the
 present is inputted in a case where the predicted load value
 5 decreases.

[0050] Still alternatively, there is a case where the
 aeration amount is desired to be reduced as much as possible
 so as to minimize the operation cost relative to the above-
 described case. In a case where the predicted load value
 10 increases, as described above, the aeration amount is
 increased in advance of increase in the load value, so that
 the operation cost increases. Therefore, control is
 performed such that the predicted load value "S'IN,N, Q'IN"
 is inputted only in a case where the predicted load value is
 15 decreased, and the load value "SIN,N, QIN" at the present is
 inputted in a case where the predicted load value increases,
 whereby the operation cost can be reduced.

[0051] According to the water treatment apparatus of
 embodiment 1 configured as described above, a water treatment
 20 apparatus for performing water treatment by supplying a
 treatment agent to treatment target water flowing into a
 water treatment tank includes:

a load measurement unit which measures, as a first
 load value, a load value of the treatment target water
 25 flowing into the water treatment tank at a first time point;

a prediction unit which predicts, as a second load value, a load value of the treatment target water flowing into the water treatment tank at a second time point after the first time point, on the basis of the first load value
5 measured by the load measurement unit; and

a supply unit which supplies the treatment agent in a supply amount corresponding to the second load value predicted by the prediction unit, to the treatment target water in the water treatment tank, at a third time point
10 between the first time point and the second time point.

In addition, a water treatment method for performing water treatment by supplying a treatment agent to treatment target water includes:

a first step of measuring, as a first load value, a
15 load value of the treatment target water at a first time point;

a second step of predicting, as a second load value, a load value of the treatment target water at a second time point after the first time point, on the basis of the
20 first load value measured in the first step; and

a third step of supplying the treatment agent in a supply amount corresponding to the second load value predicted in the second step, to the treatment target water, at a third time point between the first time point and the
25 second time point.

Thus, the treatment agent in the supply amount corresponding to the second load value is supplied at the third time point, whereby variation in the water quality of the treated water obtained through water treatment on the treatment target water can be suppressed and the operation cost can be reduced.

[0052] In addition, if the second load value at the second time point predicted by the prediction unit is determined to be greater than the first load value at the first time point, the supply unit supplies, at the third time point, the treatment agent in a larger supply amount than a supply amount of the treatment agent corresponding to the first load value at the first time point.

Thus, variation in the water quality of the treated water obtained through water treatment on the treatment target water can be assuredly suppressed.

[0053] In addition, if the second load value at the second time point predicted by the prediction unit is determined to be smaller than the first load value at the first time point, the supply unit supplies, at the third time point, the treatment agent in a smaller supply amount than a supply amount of the treatment agent corresponding to the first load value at the first time point.

Thus, variation in the water quality of the treated water obtained through water treatment on the treatment

target water can be suppressed and the operation cost can be reduced.

[0054] In addition, in a case where activated sludge is stored in the water treatment tank, the supply unit supplies
5 air as the treatment agent to the water treatment tank.

Thus, the operation cost can be assuredly reduced in the water treatment on the treatment target water using air and activated sludge.

[0055] In addition, the load measurement unit measures the
10 load value by a flow rate of the treatment target water flowing into the water treatment tank, or measures the load value by a contaminant concentration of the treatment target water flowing into the water treatment tank, or measures the load value by a product of a flow rate of the treatment
15 target water flowing into the water treatment tank and a contaminant concentration of the treatment target water flowing into the water treatment tank.

Thus, the load value of the treatment target water to be subjected to the water treatment can be assuredly
20 measured, whereby variation in the water quality of the treated water can be suppressed and the operation cost can be reduced.

[0056] Embodiment 2

FIG. 7 is a diagram showing the configuration of a
25 water treatment apparatus according to embodiment 2. In FIG.

7, the same parts as those in the above embodiment 1 are denoted by the same reference characters, and the description thereof is omitted. A concentration measurement unit 8 is provided for taking, from the pipe 102, treated water

5 discharged from the water treatment tank 1, and measuring the contaminant concentration of the treated water.

[0057] The concentration measurement unit 8 is formed by a concentration meter for a contaminant that is a water quality management target in water treatment. Specific examples
10 include an ammonia nitrogen concentration meter, a total nitrogen concentration meter, a BOD meter, and a COD meter. Further, for considering the influence of the temperature depending on the seasons or the like, a water temperature meter may be provided in addition to the contaminant
15 concentration meter. Here, a case of not providing a water temperature meter will be described.

[0058] The contaminant concentration measured by the concentration measurement unit 8 is transmitted to the calculation units 91 to 93 via a signal line 81. Therefore,
20 unlike embodiment 1 described above, the calculation units 91 to 93 have calculation formulas for calculating optimum supply amounts of the treatment agents, i.e., aeration amounts, on the basis of the first load value at the present (first time point) measured by the load measurement unit 5
25 and the contaminant concentration measured by the

concentration measurement unit 8.

[0059] Specifically, the calculation units 91 to 93 have coefficients set in advance for the aeration units 31 to 33 respectively connected thereto, and each calculate the sum of
5 the following (A), (B), and (C).

(A) A supply amount obtained by multiplying the load value of treatment target water flowing into the water treatment tank 1 measured by the load measurement unit 5, by a first coefficient set in advance for each aeration unit 31
10 to 33

(B) Constant

(C) A supply amount obtained by multiplying an operation quantity for performing feedback control so that the contaminant concentration of treated water measured by
15 the concentration measurement unit 8 becomes a predetermined target value of the contaminant concentration of treated water, by a second coefficient set in advance for each aeration unit 31 to 33

[0060] The above coefficients are values set in advance so
20 as to obtain, through the above calculation, optimum aeration amounts for causing the contaminant concentration of treated water discharged from the water treatment tank 1 to approach the predetermined target value of the contaminant concentration, and these values can be set to different
25 values in accordance with the positions or the number of the

aeration units.

[0061] For example, in a case where the load measurement unit 5 is provided with the flowmeter and the ammonia nitrogen concentration meter as the contaminant concentration meter, and the concentration measurement unit 8 is provided with the ammonia nitrogen concentration meter as the contaminant concentration meter, the first calculation unit 91 calculates a setting value G1 [Nm³/hr] for the aeration amount to be supplied from the first aeration unit 31, by the following Expression (4).

$$G1 = k11 \cdot SIN,N \cdot QIN + k12 \cdot (GP + GI + GD) + k13 \quad \dots (4)$$

SIN,N: the ammonia nitrogen concentration [mg/L] of treatment target water flowing into the water treatment tank 1

QIN: the flow rate [m³/hr] of treatment target water flowing into the water treatment tank 1

k11, k12, k13: constant

It is noted that k11 is the first coefficient and k12 is the second coefficient.

[0062] In addition, GP, GI, GD are set as shown by the following Expressions (5), (6), (7).

$$GP = KP \cdot (SOUT,N - S0,N) \quad \dots (5)$$

$$GI = KP/TI \cdot \int (SOUT,N - S0,N) dt \quad \dots (6)$$

$$GD = KP \cdot TD \cdot d(SOUT,N - S0,N)/dt \quad \dots (7)$$

SOUT,N: the ammonia nitrogen concentration [mg/L]
of treated water

S0,N: the target value [mg/L] of the ammonia
nitrogen concentration of treated water

5 KP: proportional gain

TI: integral time

TD: derivative time

[0063] Similarly as in the above case, the calculation
units 92, 93 calculate setting values G2, G3 [Nm³/hr] for the
10 aeration amounts by the following Expressions (8), (9),
respectively.

$$G2 = k21 \cdot SIN,N \cdot QIN + k22 \cdot (GP + GI + GD) + k23$$

... (8)

k21, k22, k23: constant

15 It is noted that k21 is the first coefficient and
k22 is the second coefficient.

$$G3 = k31 \cdot SIN,N \cdot QIN + k32 \cdot (GP + GI + GD) + k33$$

... (9)

k31, k32, k33: constant

20 It is noted that k31 is the first coefficient and
k32 is the second coefficient.

[0064] In the above Expressions (4), (8), (9), the first
coefficients k11, k21, k31 and the second coefficients k12,
k22, k32 set in advance correspondingly for the aeration
25 units 31 to 33 are values set in advance so as to obtain,

through the calculation, optimum aeration amounts for causing the ammonia nitrogen concentration of treated water to approach the predetermined target value of the contaminant concentration, as described above. The first coefficients

5 k11, k21, k31 and the second coefficients k12, k22, k32 are not necessarily all equal to each other, and may be set to different values in accordance with the positions of the aeration units. In addition, even after the first coefficients k11, k21, k31 and the second coefficients k12,

10 22, 32 are set once, it is possible to set optimum values again as appropriate in accordance with season change, change in a target water quality of the treated water, and the like.

[0065] As described above, the calculation units 91 to 93 calculate the aeration amounts to be supplied from the

15 aeration units 31 to 33 at the third time point between the first time point and the second time point, on the basis of the aeration amount calculation formulas provided in the calculation units 91 to 93, the second load value of treatment target water at the second time point calculated by

20 the prediction unit 7, and the contaminant concentration measured by the concentration measurement unit 8. The aeration amount calculation formulas provided in the calculation units 91 to 93 are calculation formulas for calculating optimum aeration amounts with respect to the load

25 value "SIN,N, QIN" at the present. However, in the

calculation units 91 to 93, the second load value "S'IN,N,
Q'IN" of treatment target water at the second time point,
instead of the load value at the present, is inputted in the
above calculation formulas, thereby calculating the aeration
5 amounts corresponding to the second load value of treatment
target water.

[0066] Specific description will be given on the basis of
Expressions (4), (8), (9) shown above. In Expressions (4),
(8), (9) shown above, the first load value "SIN,N, QIN" of
10 treatment target water at the present is inputted, whereby
optimum aeration amounts for the first load value of
treatment target water at the present are calculated.
However, in the calculation units 91 to 93, the second load
value "S'IN,N, Q'IN" of treatment target water predicted for
15 the second time point is inputted, to calculate target
aeration amounts (at the third time point) for the respective
aeration units 31 to 33.

[0067] The setting values G1 to G3 for the aeration
amounts at the third time point calculated as described above
20 are respectively transmitted to the supply units 41 to 43 via
the signal lines 911 to 931. The supply units 41 to 43
supply air in the amounts set respectively, via the pipes 411
to 431 and the aeration units 31 to 33, into the water
treatment tank 1.

25 [0068] As described above, after the first load value of

treatment target water at the present is measured by the load measurement unit 5, the second load value of treatment target water for the predetermined period later is calculated by the prediction unit 7, the supply amounts of the treatment agents at the third time point are calculated by the calculation units 91 to 93, the aeration amounts are controlled in the supply units 41 to 43, and air is moved through the pipes 411 to 431, whereby the target aeration amounts are supplied from the aeration units 31 to 33 to the water treatment tank 1.

At this time, until the aeration amounts at the third time point calculated by the calculation units 91 to 93 are actually supplied from the aeration units 31 to 33 after the first load value of treatment target water at the present is measured by the load measurement unit 5, there is a time lag including a calculation time for predicting the load value, a calculation time for the target value of the aeration amount, a control time for the aeration units 31 to 33, a movement time of air in the pipes, and the like. Therefore, it is necessary to set the predetermined period used for prediction of the second load value of treatment target water in the prediction unit 7 so that the time lag becomes shorter than the predetermined period. Thus, the aeration amounts can be controlled in advance before the load value actually reaches the predicted value.

[0069] In FIG. 7, the concentration measurement unit 8 is

connected to the pipe 102. However, it is only necessary that the contaminant concentration of treated water that has undergone purification treatment using the activated sludge in the water treatment tank 1 can be measured, and therefore
5 the concentration measurement unit 8 may be connected in the sedimentation tank 2 or to the pipe 103. Further, in order to assuredly prevent contaminants from flowing out with the treated water discharged from the water treatment tank 1, the concentration measurement unit 8 may be provided on the
10 downstream side in the water treatment tank 1. Thus, the contaminant concentration of treated water is controlled so as to be the target value before finishing of the purification treatment in the water treatment tank 1. As a result, more purified treated water is discharged from the
15 water treatment tank 1, whereby the water quality of the treated water can be kept preferable. This also applies in the subsequent embodiments, and the description thereof is omitted as appropriate.

[0070] The difference between the present embodiment 2 and
20 the above embodiment 1 is that calculation formulas for performing feedback control so that the contaminant concentration of treated water measured by the concentration measurement unit 8 becomes the predetermined target value of the contaminant concentration of treated water, are added to
25 the aeration amount calculation formulas (1) to (3). Thus,

it becomes possible to finely control the contaminant concentration, whereby not only variation in the water quality of treated water due to variation in the load value can be further suppressed but also energy consumption of the supply units 41 to 43 and the aeration units 31 to 33 can be suppressed owing to aeration without excess and insufficiency.

[0071] As described above, not only the load value of the treatment target water flowing into the water treatment tank 1 is predicted and the aeration amount to be supplied into the water treatment tank 1 is set on the basis of the predicted load value, but also calculation for performing feedback control with respect to the contaminant concentration of treated water that has undergone water treatment is added, whereby it is possible to finely control the contaminant concentration in accordance with the target value and set the aeration amount without excess and insufficiency. Further, in a case where the water quality of treated water is desired to be kept as preferable as possible, in order to prevent the water quality of treated water from being temporarily deteriorated when the aeration amount is decreased in advance in a case where the load value decreases, control may be performed such that the predicted load value "S'IN,N, Q'IN" is inputted only in a case where the predicted load value increases, and the load value

"SIN,N, QIN" at the present is inputted in a case where the predicted load value decreases. Meanwhile, in a case where the aeration amount is desired to be reduced as much as possible so as to minimize the operation cost, increasing the aeration amount in advance in a case where the load value increases leads to increase in the operation cost.

Therefore, control may be performed such that the predicted load value "S'IN,N, Q'IN" is inputted only in a case where the load value decreases, and the load value "SIN,N, QIN" at the present is inputted in a case where the load value increases.

[0072] The water treatment apparatus of embodiment 2 configured as described above provides, as a matter of course, the same effects as those in the above embodiment 1, and also, the water treatment apparatus further includes a concentration measurement unit which measures a contaminant concentration of treated water obtained through the water treatment on the treatment target water in the water treatment tank, and

the supply unit supplies the treatment agent in a supply amount for which the contaminant concentration of the treated water obtained through the water treatment in the water treatment tank, measured by the concentration measurement unit, is taken into consideration.

Thus, the contaminant concentration of the treated

water obtained through the water treatment in the water treatment tank is taken into consideration for the supply amount of the treatment agent, whereby it is possible to further suppress variation in the water quality of the treated water obtained through the water treatment on the treatment target water and further reduce the operation cost.

[0073] Embodiment 3

FIG. 8 is a diagram showing the configuration of a water treatment apparatus according to embodiment 3. In FIG. 8, the same parts as those in the above embodiments are denoted by the same reference characters, and the description thereof is omitted. The water treatment apparatus in the present embodiment 3 is a water treatment apparatus which supplies ozone gas as the treatment agent to treatment target water, to oxidize and decompose contaminants in the treatment target water. In the present embodiment 3, since ozone gas is used as the treatment agent, unlike the above embodiments, activated sludge is not needed for the water treatment tank 1 and thus the sedimentation tank 2 and the configuration relevant to the sedimentation tank 2 are not present.

[0074] In the present embodiment 3, since ozone gas is used as the treatment agent, the supply amount may be referred to as an ozone gas concentration. The supply unit in the present embodiment 3 is composed of the aeration units 31 to 33, a supply unit 44, and a calculation unit 94.

[0075] The load measurement unit 5 includes at least one measurement device of a flowmeter or a contaminant concentration meter (an organic substance concentration meter, an odor substance concentration meter, a color meter, a virus detector, etc.). The load measurement unit 5 measures the load value continuously or intermittently at predetermined time intervals, as in the above embodiments. All the load values are associated with times at which the load values are measured. The load measurement unit 5 may include both of the flowmeter and the contaminant concentration meter described above. In this case, the product of the flow rate and the contaminant concentration of the treatment target water flowing into the water treatment tank 1 may be calculated as the load value. Thus, the load measurement unit 5 measures the load value of the treatment target water substantially flowing into the water treatment tank 1. As an alternative for the flowmeter, the opening degree of a weir of an inflow ditch may be used instead of the flow rate. Further, for considering the influence of the temperature depending on the seasons or the like, a water temperature meter may be provided in addition to the flowmeter and the contaminant concentration meter. Here, a case of not providing a water temperature meter will be described.

[0076] The concentration measurement unit 8 is formed by a

concentration meter for a contaminant that is a water quality management target in water treatment. Specific examples include an organic substance concentration meter, an odor substance concentration meter, a color meter, and a virus detector. Further, for considering the influence of the temperature depending on the seasons or the like, a water temperature meter may be provided in addition to the contaminant concentration meter. Here, a case of not providing a water temperature meter will be described.

10 [0077] The supply unit 44 supplies ozone gas as the treatment agent. The supply unit 44 generates ozone gas by means of electric discharge, an ultraviolet lamp, or the like, using air or oxygen as source gas, for example. In a case of using oxygen as source gas, nitrogen, air, or carbon dioxide may be added as necessary in an amount of 0.05% to 5% relative to the flow rate of oxygen to be supplied.

[0078] The calculation unit 94 has a calculation formula for calculating the ozone gas concentration of the treatment agent to be supplied from each aeration unit 31 to 33 at the third time point between the first time point and the second time point, using the first load value of treatment target water at the present as the first time point, measured by the load measurement unit 5, or the second load value of treatment target water for the predetermined period later as the second time point after the first time point, predicted

by the prediction unit 7. In addition, the supply unit 44 has a function of controlling its output by an inverter or the like so that the concentration of ozone gas supplied from the supply unit 44 becomes the ozone gas concentration

5 calculated by the calculation unit 94.

[0079] In the water treatment method of the water treatment apparatus of embodiment 3 configured as described above, treatment target water flowing in via the pipe 101 is mixed and stirred with ozone gas in the water treatment tank 1, so that contaminants in the water are oxidized and decomposed, whereby purification treatment is performed.

[0080] Next, calculation in the calculation unit 94 will be specifically described. The calculation unit 94 calculates the sum of the following (A), (B), and (C).

15 (A) A supply amount obtained by multiplying the load value of treatment target water flowing into the water treatment tank 1 measured by the load measurement unit 5, by a predetermined first coefficient

(B) Constant

20 (C) A supply amount obtained by multiplying an operation quantity for performing feedback control so that the contaminant concentration of treated water measured by the concentration measurement unit 8 becomes a predetermined target value of the contaminant concentration of treated
25 water, by a predetermined second coefficient

[0081] The above coefficients are values set in advance so as to obtain, through the above calculation, an optimum ozone gas concentration for causing the contaminant concentration of treated water discharged from the water treatment tank 1 to approach the predetermined target value of the contaminant concentration.

[0082] For example, in a case where the load measurement unit 5 is provided with the flowmeter and the organic substance concentration meter (ultraviolet absorption spectrometer, etc.), and the concentration measurement unit 8 is provided with the organic substance concentration meter, the calculation unit 94 calculates a setting value SO3 [g/Nm³] for the ozone gas concentration of ozone gas to be supplied from the aeration units 31 to 33, by the following Expression (10).

$$SO3 = k1 \cdot SIN,TOC \cdot QIN + k2 \cdot (GP + GI + GD) + k3 \dots (10)$$

SIN,TOC: the organic substance concentration measured value [mg/L] of treatment target water flowing into the water treatment tank

QIN: the flow rate measured value [m³/hr]

k1, k2, k3: constant

It is noted that k1 is the first coefficient and k2 is the second coefficient.

[0083] In addition, GP, GI, GD are set as shown by the

following Expressions (11), (12), (13).

$$GP = KP \cdot (SOUT, TOC - S0, TOC) \quad \dots (11)$$

$$GI = KP/TI \cdot \int (SOUT, TOC - S0, TOC) dt \quad \dots (12)$$

$$GD = KP \cdot TD \cdot d(SOUT, TOC - S0, TOC) / dt \quad \dots (13)$$

5 SOUT, TOC: the organic substance concentration
measured value [mg/L] of treated water

 S0, TOC: the target value [mg/L] of the organic
substance concentration in the treatment

 KP: proportional gain

10 TI: integral time

 TD: derivative time coefficient

[0084] Even after k1, k2, k3 are set once, it is possible
to set optimum values again as appropriate in accordance with
change in the water temperature or a target water quality of
15 treated water, and the like. The calculation unit 94
calculates the target value of the concentration of ozone gas
to be supplied from the aeration units 31 to 33, on the basis
of the ozone gas concentration calculation formula provided
in the calculation unit 94, the second load value of
20 treatment target water at the second time point calculated by
the prediction unit 7, and the contaminant concentration of
treated water measured by the concentration measurement unit
8.

[0085] The ozone gas concentration calculation formula
25 provided in the calculation unit 94 is a calculation formula

for calculating an optimum ozone gas concentration with respect to the first load value at the present (first time point). However, in the calculation unit 94, the second load value "S'IN,TOC, Q'IN" of treatment target water at the second time point, instead of the first load value "SIN,TOC, QIN" of treatment target water at the present, is inputted in the above calculation formula, thereby calculating the concentration of ozone gas to be supplied.

[0086] Specific description will be given on the basis of Expression (10) shown above. In Expression (10) shown above, the first load value "SIN,TOC, QIN" of treatment target water at the present is inputted, whereby an optimum ozone gas concentration for the first load value of treatment target water at the present is calculated. However, in the calculation unit 94, the second load value "S'IN,TOC, Q'IN" of treatment target water at the second time point is inputted, to calculate the ozone gas concentration of ozone gas to be supplied from the aeration units 31 to 33.

[0087] The setting value SO3 for the ozone gas concentration calculated as described above is transmitted to the supply unit 44 via a signal line 941. The supply unit 44 supplies ozone gas with the set concentration into the water treatment tank 1 via the pipes 441 to 443 and the aeration units 31 to 33. After the first load value of treatment target water at the present is measured by the load

measurement unit 5, the second load value of treatment target water for the predetermined period later is predicted by the prediction unit 7, the target value of the supply amount of the treatment agent is calculated by the calculation unit 94, ozone gas concentration control is performed in the supply unit 44, and ozone gas is moved through the pipes 441 to 443, whereby ozone gas with the target ozone gas concentration is supplied from the aeration units 31 to 33 to the water treatment tank 1.

10 [0088] At this time, until ozone gas with the ozone gas concentration calculated by the calculation unit 94 is actually supplied from the aeration units 31 to 33 after the first load value of treatment target water at the present is measured by the load measurement unit 5, there is a time lag including a calculation time for flow-in prediction, a calculation time for the ozone gas concentration, a control time for an ozone generator, a movement time of ozone gas in the pipes, and the like. Here, it is necessary to set the predetermined period used for prediction of the second load value of treatment target water in the prediction unit 7 so that the time lag becomes shorter than the predetermined period. Thus, the ozone gas concentration can be controlled in advance before the load value actually reaches the predicted value.

25 [0089] The second load value of treatment target water at

the second time point is inputted in the above Expression (10). Thus, in a case where the second load value of treatment target water at the second time point becomes greater than the first load value at the first time point, at a stage when the second load value of treatment target water is predicted to increase (at the third time point between the first time point and the second time point), the ozone gas concentration is increased in advance before the load value actually increases. As a result, treatment target water with high load flows into the water treatment tank 1 in a state in which the dissolved ozone gas concentration in the water treatment tank 1 is sufficiently increased.

[0090] Thus, the treatment target water with high load is purified immediately, whereby deterioration in the water quality of treated water due to increase in the load value can be suppressed. On the other hand, in a case where the second load value of treatment target water at the second time point becomes smaller than the first load value at the first time point, at a stage when the load value is predicted to decrease (at the third time point between the first time point and the second time point), the ozone gas concentration is decreased before the load value actually decreases. Since the ozone gas concentration is decreased beforehand, the water quality of treated water is temporarily deteriorated, but thereafter, treatment target water with decreased load

flows into the water treatment tank 1. Therefore, the water quality of treated water does not exceed the upper limit value for management, and excessive supply of ozone gas can be suppressed while the water quality of treated water is kept preferable.

[0091] Further, through calculation for performing feedback control so that the contaminant concentration of treated water measured by the concentration measurement unit 8 becomes the predetermined target value of the contaminant concentration of treated water, it becomes possible to finely control the contaminant concentration of treated water in accordance with the target value. Thus, not only variation in the water quality of treated water due to variation in the load value can be further suppressed but also the source material for ozone gas and energy required for generating ozone can be reduced owing to ozone gas supply without excess and insufficiency.

[0092] As described above, the second load value of treatment target water flowing into the water treatment tank 1 is predicted, and the ozone gas concentration of ozone gas to be supplied into the water treatment tank 1 at the third time point is set on the basis of the predicted second load value of treatment target water. Therefore, in a case where the second load value of treatment target water increases, the ozone gas concentration is increased in advance, whereby

deterioration in the water quality of treated water can be suppressed. In addition, in a case where the second load value of treatment target water decreases, the ozone gas concentration is decreased in advance, whereby excessive
5 supply of ozone gas can be suppressed while the water quality of treated water is kept below the upper limit value for management.

[0093] Further, in a case where the water quality of treated water is desired to be kept as preferable as
10 possible, in order to prevent the water quality of treated water from being temporarily deteriorated when the ozone gas concentration is decreased in advance in a case where the load value decreases, control may be performed such that the second load value "S'IN,TOC, Q'IN" is inputted only in a case
15 where the second load value of treatment target water increases, and the first load value "SIN,TOC, QIN" of treatment target water at the present is inputted in a case where the second load value of treatment target water decreases.

20 [0094] Meanwhile, in a case where supply of ozone gas is desired to be reduced as much as possible so as to minimize the operation cost, increasing the ozone gas concentration in advance in a case where the second load value of treatment target water increases leads to increase in the operation
25 cost. Therefore, control may be performed such that the

predicted load value "S'IN,TOC, Q'IN" is inputted only in a case where the second load value of treatment target water decreases, and the first load value "SIN,TOC, QIN" of treatment target water at the present is inputted in a case
5 where the second load value of treatment target water increases.

[0095] The water treatment apparatus of embodiment 3 configured as described above provides, as a matter of course, the same effects as those in the above embodiments.

10 In addition, in a case where at least one of organic substance removal, odor substance removal, virus removal, or decoloring is performed as the water treatment on the treatment target water, the supply unit supplies ozone gas as the treatment agent to the water treatment tank.

15 Thus, it is possible to suppress variation in the water quality of treated water and reduce the operation cost in water treatments such as organic substance removal, odor substance removal, virus removal, and decoloring for the treatment target water.

20 [0096] Embodiment 4

FIG. 9 is a diagram showing the configuration of a water treatment apparatus according to embodiment 4. In FIG. 9, the same parts as those in the above embodiments are denoted by the same reference characters, and the description
25 thereof is omitted. The water treatment apparatus in the

present embodiment 4 is a water treatment apparatus which supplies a flocculant as the treatment agent to treatment target water, to react contaminants in the treatment target water with the flocculant, thereby settling the contaminants as a metal salt and a calcium salt and thus performing purification treatment. In the present embodiment 4, since the flocculant is used as the treatment agent, unlike the above embodiments, the aeration units 31 to 33 and the configuration relevant to the aeration units 31 to 33 are not present. The supply unit in the present embodiment 4 is composed of a treatment agent tank 45, a supply unit 46, and a calculation unit 95.

[0097] The load measurement unit 5 includes at least one measurement device of a flowmeter or a contaminant concentration meter (a phosphate phosphorus concentration meter, a total phosphorus concentration meter, etc.). The load measurement unit 5 measures the load value continuously or intermittently at predetermined time intervals, as in the above embodiments. All the load values are associated with times at which the load values are measured. The load measurement unit 5 may include both of the flowmeter and the contaminant concentration meter described above. In this case, the product of the flow rate and the contaminant concentration of the treatment target water flowing into the water treatment tank 1 may be calculated as the load value.

Thus, the load measurement unit 5 measures the load value of the treatment target water substantially flowing into the water treatment tank 1. As an alternative for the flowmeter, the opening degree of a weir of an inflow ditch may be used instead of the flow rate. Further, for considering the influence of the temperature depending on the seasons or the like, a water temperature meter may be provided in addition to the flowmeter and the contaminant concentration meter. Here, a case of not providing a water temperature meter will be described.

[0098] The concentration measurement unit 8 is mounted to the pipe 103 and measures the contaminant concentration of treated water discharged from the sedimentation tank 2. The concentration measurement unit 8 is formed by a concentration meter for a contaminant to be cleaned out by the flocculant among contaminants that are water quality management targets in the water treatment. Specific examples include a phosphate phosphorus concentration meter and a total phosphorus concentration meter. Further, for considering the influence of the temperature depending on the seasons or the like, a water temperature meter may be provided in addition to the contaminant concentration meter. Here, a case of not providing a water temperature meter will be described.

[0099] The treatment agent tank 45 stores a flocculant as the treatment agent. Examples of the types of the flocculant

include poly aluminum chloride (PAC), ferric chloride, poly ferric sulfate, and iron hydroxide. The supply unit 46 receives the flocculant stored in the treatment agent tank 45 via a pipe 451 by a pump, and supplies the flocculant into the water treatment tank 1 via a pipe 461.

[0100] The calculation unit 95 has a calculation formula for calculating an optimum supply amount of the flocculant to be supplied from the supply unit 46 on the basis of the first load value of treatment target water at the present as the first time point, measured by the load measurement unit 5, and the contaminant concentration measured by the concentration measurement unit 8. The supply amount calculated by the calculation unit 95 is transmitted to the supply unit 46 via a signal line 951. In addition, the supply unit 46 has a function of controlling the supply amount by an inverter or the like so that the supply amount of the flocculant supplied from the supply unit 46 becomes the supply amount calculated by the calculation unit 95.

[0101] In the water treatment method of the water treatment apparatus of embodiment 4 configured as described above, the flocculant is supplied to the water treatment tank 1, whereby contaminants such as phosphorus that can be cleaned out by chemical flocculation reaction are settled and separated in the sedimentation tank 2, thus performing purification treatment for contaminants in the treatment

target water.

[0102] Next, calculation in the calculation unit 95 will be specifically described. The calculation unit 95 calculates the sum of the following (A), (B), and (C).

5 (A) A supply amount obtained by multiplying the load value of treatment target water flowing into the water treatment tank 1 measured by the load measurement unit 5, by a predetermined first coefficient

(B) Constant

10 (C) A supply amount obtained by multiplying an operation quantity for performing feedback control so that the contaminant concentration of treated water measured by the concentration measurement unit 8 becomes a predetermined target value of the contaminant concentration of treated
15 water, by a predetermined second coefficient

[0103] The above coefficients are values set in advance so as to obtain, through the above calculation, an optimum supply amount of the flocculant for causing the contaminant concentration of treated water discharged from the water
20 treatment tank 1 to more approach the predetermined target value of the contaminant concentration of treated water.

[0104] For example, in a case where the load measurement unit 5 is provided with the flowmeter and the phosphate phosphorus concentration meter, and the concentration
25 measurement unit 8 is provided with the phosphate phosphorus

concentration meter, the calculation unit 95 calculates a setting value QF [g/nm³] for the supply amount of the flocculant to be supplied from the supply unit 46 by the following Expression (14).

$$QF = k1 \cdot SIN,P \cdot QIN + k2 \cdot (GP + GI + GD) + k3 \quad \dots (14)$$

SIN,P : phosphate phosphorus concentration measured value [mg/L] of treatment target water flowing into the water treatment tank

10 QIN : the flow rate measured value [m³/hr]

$k1, k2, k3$: constant

It is noted that $k1$ is the first coefficient and $k2$ is the second coefficient.

[0105] In addition, GP, GI, GD are set as shown by the following Expressions (15), (16), (17).

$$GP = KP \cdot (SOUT,P - S0,P) \quad \dots (15)$$

$$GI = KP/TI \cdot \int (SOUT,P - S0,P) dt \quad \dots (16)$$

$$GD = KP \cdot TD \cdot d(SOUT,P - S0,P)/dt \quad \dots (17)$$

20 $SOUT,P$: the phosphate phosphorus concentration measured value [mg/L] of flowed-out water

$S0,P$: the target value [mg/L] of the phosphate phosphorus concentration of flowed-out water

KP : proportional gain

TI : integral time

25 TD : derivative time coefficient

[0106] Even after k_1 , k_2 , k_3 are set once, it is possible to set optimum values again as appropriate in accordance with change in the water temperature or a target value of treated water, and the like. The calculation unit 95 calculates the target value of the supply amount of the flocculant to be supplied from the supply unit 46, on the basis of the flocculant supply amount calculation formula provided in the calculation unit 95, the second load value at the second time point calculated by the prediction unit 7, and the contaminant concentration of treated water measured by the concentration measurement unit 8.

[0107] The flocculant supply amount calculation formula provided in the calculation unit 95 is a calculation formula for calculating an optimum supply amount of the flocculant with respect to the first load value of treatment target water at the present (first time point). However, in the calculation unit 95, the second load value " $S'_{IN,P}$, Q'_{IN} " of treatment target water at the second time point, instead of the first load value " $S_{IN,P}$, Q_{IN} " of treatment target water at the present, is inputted in the above calculation formula, thereby calculating the supply amount of the flocculant.

[0108] Specific description will be given on the basis of Expression (14) shown above. In Expression (14) shown above, the first load value " $S_{IN,P}$, Q_{IN} " of treatment target water at the present is inputted, whereby an optimum supply amount

of the flocculant for the first load value of treatment target water at the present is calculated. However, in the calculation unit 95, the second load value "S'IN,P, Q'IN" of treatment target water is inputted, to calculate the supply
5 amount of the flocculant to be supplied from the supply unit 46.

[0109] The setting value QF for the supply amount of the flocculant calculated as described above is transmitted to the supply unit 46 via the signal line 951. The supply unit
10 46 supplies the flocculant into the water treatment tank 1. After the first load value at the present is measured by the load measurement unit 5, the second load value for the predetermined period later is measured by the prediction unit 7, the target value of the supply amount of the treatment
15 agent is calculated by the calculation unit 95, and flocculant supply amount control is performed in the supply unit 46, whereby the flocculant in the target supply amount is supplied to the water treatment tank 1.

[0110] At this time, until the flocculant in the supply
20 amount calculated by the calculation unit 95 is actually supplied after the first load value at the present is measured by the load measurement unit 5, there is a time lag including a calculation time for flow-in prediction, a calculation time for the supply amount of the flocculant, a
25 control time for the supply unit 46, and the like. Here, it

is necessary to set the predetermined period used for prediction of the second load value in the prediction unit 7 so that the time lag becomes shorter than the predetermined period. Thus, the supply amount of the flocculant can be controlled in advance before the second load value actually reaches the predicted value.

[0111] In the present embodiment, the case of cleaning out phosphorus is described. However, the same treatment can be applied to contaminants such as fluorine, boron, and heavy metal that can be chemically flocculated by being supplied with the flocculant, besides phosphorus.

[0112] The second load value of treatment target water at the second time point is inputted in the above Expression (14). Thus, in a case where the second load value of treatment target water at the second time point increases, at a stage when the second load value of treatment target water at the second time point is predicted to increase (at the third time point between the first time point and the second time point), the supply amount of the flocculant is increased in advance before the load value actually increases. As a result, treatment target water with high load flows into the water treatment tank 1 in a state in which the flocculant is sufficiently supplied in the water treatment tank 1 and the sedimentation tank 2.

[0113] Thus, the treatment target water with high load is

purified immediately, whereby deterioration in the water quality of treated water due to increase in the load value can be suppressed. On the other hand, in a case where the second load value of treatment target water at the second
5 time point decreases, at a stage when the load value is predicted to decrease (at the third time point between the first time point and the second time point), the supply amount of the flocculant is decreased before the load value actually decreases. Since the supply amount of the
10 flocculant is decreased beforehand, the water quality of treated water is temporarily deteriorated, but thereafter, treatment target water with decreased load flows into the water treatment tank 1. Therefore, the water quality of treated water does not exceed the upper limit value for
15 management, and excessive supply of the flocculant can be suppressed while the water quality of treated water is kept preferable.

[0114] Further, through calculation for performing feedback control so that the contaminant concentration
20 measured by the concentration measurement unit 8 becomes the predetermined target value of the contaminant concentration, it becomes possible to finely control the contaminant concentration in accordance with the target value. Thus, not only variation in the water quality of treated water due to
25 variation in the load value can be further suppressed but

also the usage amount of the flocculant can be reduced owing to flocculant supply without excess and insufficiency.

[0115] As described above, the second load value of treatment target water flowing into the water treatment tank 1 is predicted, and the supply amount of the flocculant to be supplied into the water treatment tank 1 at the third time point is set on the basis of the predicted second load value of treatment target water. Therefore, in a case where the second load value of treatment target water increases, the supply amount of the flocculant is increased in advance, whereby deterioration in the water quality of treated water can be suppressed. In addition, in a case where the second load value of treatment target water decreases, the supply amount of the flocculant is decreased in advance, whereby excessive supply of the flocculant can be suppressed while the water quality of treated water is kept below the upper limit value for management.

[0116] Further, in a case where the water quality of treated water is desired to be kept as preferable as possible, in order to prevent the water quality of treated water from being temporarily deteriorated when the supply amount of the flocculant is decreased in advance in a case where the second load value of treatment target water decreases, control may be performed such that the second load value "S'IN,P, Q'IN" of treatment target water is inputted

only in a case where the load value increases, and the first load value "SIN,P, QIN" of treatment target water at the present is inputted in a case where the load value decreases.

[0117] Meanwhile, in a case where supply of the flocculant
5 is desired to be reduced as much as possible so as to minimize the operation cost, increasing the supply amount of the flocculant in advance in a case where the second load value of treatment target water increases leads to increase in the operation cost. Therefore, control may be performed
10 such that the predicted second load value "S'IN,P, Q'IN" of treatment target water is inputted only in a case where the second load value of treatment target water decreases, and the first load value "SIN,P, QIN" of treatment target water at the present is inputted in a case where the second load
15 value of treatment target water increases.

[0118] The water treatment apparatus of embodiment 4 configured as described above provides, as a matter of course, the same effects as those in the above embodiments.

In addition, in a case where contaminants in the
20 treatment target water are settled and separated through chemical flocculation reaction as the water treatment on the treatment target water, the supply unit supplies a flocculant as the treatment agent to the water treatment tank.

Thus, it is possible to suppress variation in the
25 water quality of treated water and reduce the operation cost

in sedimentation separation water treatment through chemical flocculation reaction between the flocculant and contaminants in the treatment target water.

[0119] Although the disclosure is described above in terms of various exemplary embodiments and implementations, it should be understood that the various features, aspects, and functionality described in one or more of the individual embodiments are not limited in their applicability to the particular embodiment with which they are described, but instead can be applied, alone or in various combinations to one or more of the embodiments of the disclosure.

It is therefore understood that numerous modifications which have not been exemplified can be devised without departing from the scope of the present disclosure. For example, at least one of the constituent components may be modified, added, or eliminated. At least one of the constituent components mentioned in at least one of the preferred embodiments may be selected and combined with the constituent components mentioned in another preferred embodiment.

DESCRIPTION OF THE REFERENCE CHARACTERS

[0120] 1 water treatment tank
101 pipe
25 102 pipe

	103	pipe
	104	pipe
	105	pipe
	2	sedimentation tank
5	31	first aeration unit
	32	second aeration unit
	33	third aeration unit
	41	first supply unit
	411	pipe
10	42	second supply unit
	421	pipe
	43	third supply unit
	431	pipe
	44	supply unit
15	45	treatment agent tank
	451	pipe
	46	supply unit
	461	pipe
	5	load measurement unit
20	51	signal line
	52	signal line
	6	recording unit
	61	signal line
	7	prediction unit
25	71	signal line

	8	concentration measurement unit
	81	signal line
	91	first calculation unit
	911	signal line
5	92	second calculation unit
	921	signal line
	93	third calculation unit
	931	signal line
	94	calculation unit
10	941	signal line
	95	calculation unit
	951	signal line

CLAIMS

[1] A water treatment apparatus for performing water treatment by supplying a treatment agent to treatment target water flowing into a water treatment tank, the water

5 treatment apparatus comprising:

a load measurement unit which measures, as a first load value, a load value of the treatment target water flowing into the water treatment tank at a first time point;

a prediction unit which predicts, as a second load
10 value, a load value of the treatment target water flowing into the water treatment tank at a second time point after the first time point, on the basis of the first load value measured by the load measurement unit; and

a supply unit which

15 in a case where the second load value becomes greater than the first load value, calculates a supply amount of the treatment agent corresponding to the second load value,

in a case where the second load value becomes
20 smaller than the first load value, calculates a supply amount of the treatment agent corresponding to the first load value, and

supplies the treatment agent in the calculated supply amount, to the treatment target water in the water
25 treatment tank, at a third time point between the first time

point and the second time point.

[2] The water treatment apparatus according to claim 1,
wherein

5 in a case where activated sludge is stored in the
water treatment tank, the supply unit supplies air as the
treatment agent to the water treatment tank.

[3] The water treatment apparatus according to claim 1,
10 wherein

in a case where at least one of organic substance
removal, odor substance removal, virus removal, or decoloring
is performed as the water treatment on the treatment target
water, the supply unit supplies ozone gas as the treatment
15 agent to the water treatment tank.

[4] The water treatment apparatus according to claim 1,
wherein

in a case where contaminants in the treatment
20 target water are settled and separated through chemical
flocculation reaction as the water treatment on the treatment
target water, the supply unit supplies a flocculant as the
treatment agent to the water treatment tank.

25 [5] The water treatment apparatus according to claims 1

to 4, wherein

the load measurement unit measures the load value by a flow rate of the treatment target water flowing into the water treatment tank, or measures the load value by a
5 contaminant concentration of the treatment target water flowing into the water treatment tank, or measures the load value by a product of a flow rate of the treatment target water flowing into the water treatment tank and a contaminant concentration of the treatment target water flowing into the
10 water treatment tank.

[6] The water treatment apparatus according to any one of claims 1 to 5, further comprising a concentration measurement unit which measures a contaminant concentration
15 of treated water obtained through the water treatment on the treatment target water in the water treatment tank, wherein the supply unit supplies the treatment agent in a supply amount for which the contaminant concentration of the treated water measured by the concentration measurement unit
20 is taken into consideration.

[7] A water treatment method for performing water treatment by supplying a treatment agent to treatment target water, the water treatment method comprising:
25 a first step of measuring, as a first load value, a

load value of the treatment target water at a first time point;

a second step of predicting, as a second load value, a load value of the treatment target water at a second
5 time point after the first time point, on the basis of the first load value measured in the first step; and

a third step of

in a case where the second load value becomes greater than the first load value, calculating a supply
10 amount of the treatment agent corresponding to the second load value,

in a case where the second load value becomes smaller than the first load value, calculating a supply
amount of the treatment agent corresponding to the first load
15 value, and

supplying the treatment agent in the calculated supply amount, to the treatment target water, at a third time point between the first time point and the second time point.