DESCRIPTION

WATER TREATMENT APPARATUS AND WATER TREATMENT METHOD

Field

[0001] The present invention relates to a biological water treatment apparatus and to a biological water treatment method for purifying urban sewage, organic wastewater, and nitrogen-containing wastewater using a biological treatment.

Background

[0002] One typical method of treatment of urban sewage, organic wastewater, and nitrogen-containing wastewater is an activated sludge process. An activated sludge process is a process in which a microorganism group (activated sludge) having a purification effect is stored in a bioreactor tank, and aeration is provided while this and wastewater are mixed together in contact with each other to oxidize and decompose pollutants in the wastewater. To achieve a sufficient degree of purification of these pollutants, an appropriate amount of air needs to be supplied to the bioreactor tank. Such air supply to a bioreactor tank is known as aeration.

Energy required for aeration accounts for a significant portion of the energy in water treatment that uses an activated sludge process. To increase energy efficiency in water treatment, a method has been proposed for a conventional water treatment system, in which the overall aeration air volume is reduced by improving followability of the ammonia-degrading potential to a variation in the ammonia nitrogen concentration of the aerobic tank. Specifically, a method has been proposed in

which a first ammonia meter for measuring the ammonia nitrogen concentration of the raw water, an aeration air volume computation unit that calculates a target operational volume, and an aeration air volume control unit that controls the aeration air volume based on the target operational volume are included, and the aeration air volume computation unit computes an aeration air volume using a feedforward control system that operates based on the raw water ammonia nitrogen concentration and a feedback control system that provides feedback control based on the aerobic tank ammonia nitrogen concentration (see, e.g., Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent Application Laid-open No. 2012-66231

Summary

Technical Problem

[0004] A conventional water treatment apparatus such as one described above is required to further reduce the amount of energy required for aeration to increase energy efficiency in water treatment. For example, the conventional water treatment apparatus aerates the aerobic tank uniformly over the entire volume thereof at an aeration air volume computed based on the ammonia nitrogen concentration in the raw water or on the ammonia nitrogen concentration in the aerobic tank. The aerobic tank is often aerated uniformly over the entire volume thereof for simplicity of apparatus design in view of a generally complex configuration of a water treatment apparatus. However, the raw water flowed into the aerobic tank is

sequentially treated over time in the downstream direction in the aerobic tank. This results in different reaction rates in the biological reaction occurring in the bioreactor tank depending on positions in the aerobic tank, thereby causing the required aeration air volume to also differ depending on the position in the aerobic tank. Thus, the conventional water treatment apparatus fails to supply air at an appropriate aeration air volume depending on the position in the aerobic tank. A further reduction in the amount of energy required for aeration has then been demanded by efficient adjustment of the aeration air volume.

[0005] The present invention has been made in view of the above-described situation, and it is an object of the present invention to provide a biological water treatment apparatus and a biological water treatment method that enable a further reduction in the amount of energy required for aeration.

Solution to Problem

[0006] A water treatment apparatus according to the present invention includes: a first aeration unit and a second aeration unit to each aerate the treatment target water with the air, in a bioreactor tank that aerates, with air, treatment target water that flows into the bioreactor tank through an inlet, performs biological reaction treatment, and drains the treatment target water out of the bioreactor tank through a drain port; and an aeration rate calculation unit to control an aeration rate of the first aeration unit and an aeration rate of the second aeration unit, wherein the first aeration unit is disposed at a position less distant from the inlet than the second aeration unit in the bioreactor tank, and the aeration rate calculation unit provides control to produce different

aeration rates for the first aeration unit and the second aeration unit.

[0007] A water treatment method according to the present invention includes: a step of measuring an influent load of treatment target water that flows into a bioreactor tank; a step of measuring an effluent pollutant concentration of the treatment target water that flows out of the bioreactor tank; a step of calculating, based on the influent load, an inlet-side controlled aeration rate of each of a plurality of aeration units to produce different inlet-side controlled aeration rates for the respective aeration units, and a step of calculating, based on the effluent pollutant concentration, an outlet-side controlled aeration rates of each of the aeration units to produce different outlet-side controlled aeration rates for the respective aeration units, the aeration units being disposed along a direction of flow of the treatment target water in the bioreactor tank; a step of determining an aeration rate for each corresponding one of the aeration units by adding together the inlet-side controlled aeration rate and the outlet-side controlled aeration rate; and a step in which each of the aeration units supplied with air that corresponds to a corresponding one of the aeration rates aerates the treatment target water with the air.

Advantageous Effects of Invention

[0008] The present invention enables a biological water treatment apparatus and a water treatment method to be provided that enable a further reduction in the amount of energy required for aeration.

[0009] In addition, a water treatment method according to the present invention enables the pollutant concentration of effluent water that is to be drained to be

finely controlled, and also enables the treatment water quality to be efficiently controlled using a proper aeration rate, enables an appropriate aeration rate to be set depending on the position of each aeration unit in the reactor tank, enables water quality to be efficiently controlled, enables an appropriate amount of air to be supplied from each aeration unit of the reactor tank even under variation in the influent load of treatment target water flowing in, and thus enables the pollutant concentration of effluent water that is to be drained to be brought closer to a target value.

Brief Description of Drawings

[0010] FIG. 1 is a configuration diagram of a water treatment apparatus according to a first embodiment of the present invention.

FIG. 2 is a configuration diagram of a water treatment apparatus according to a second embodiment of the present invention.

FIG. 3 is a configuration diagram of the aeration rate calculation unit according to the second embodiment of the present invention.

FIG. 4 is a configuration diagram of a water treatment apparatus according to a third embodiment of the present invention.

FIG. 5 is a configuration diagram of the aeration rate calculation unit according to the third embodiment of the present invention.

Description of Embodiments

[0011] First Embodiment.

A water treatment apparatus according to a first embodiment of the present invention will be described with

reference to FIG. 1. FIG. 1 is a configuration diagram of a biological water treatment apparatus.

[0012] Referring to FIG. 1, treatment target water flowed in through a pipe 103 is purified by biological reaction in a bioreactor tank 1 storing activated sludge, and purification-treated effluent water is drained through a pipe 106. The activated sludge contained in the effluent water drained out of the bioreactor tank 1 through the pipe 106 is let to settle in a settling tank 2. The supernatant water obtained after the settling treatment is drained through a pipe 108. In addition, the activated sludge separated by the settling treatment is returned to the bioreactor tank 1 through a pipe d, while the residue is drained out to the outside world through a pipe e.

The bioreactor tank 1 includes an anaerobic zone 101, where no aeration is performed, upstream of the bioreactor tank 1. Downstream of the anaerobic zone, an aerobic zone 102 including aeration units disposed therein is provided, where air supplied from the aeration units and the activated sludge are mixed together. The water treatment apparatus according to the first embodiment includes a partition plate 100 between the anaerobic zone 101 and the aerobic zone 102. Use of the partition plate 100 allows air from the aeration units 30 to be reliably prevented from leaking out into the anaerobic zone 101. It is therefore likely that the anaerobic nature of the anaerobic zone 101 is maintained at a high level. The configuration of the present invention is not limited to the configuration of this example, and the partition plate 100 may be omitted. Alternatively, separation may be achieved by use of separate water tanks or circuit structures instead of the use of the partition plate 100.

The water treatment apparatus according to the first

embodiment includes the multiple aeration units 30 (i.e., a first aeration unit 31, a second aeration unit 32, and a third aeration unit 33) along the flow direction of the treatment target water in the aerobic zone 102 in the bioreactor tank 1. The first aeration unit is disposed at a position less distant from the inlet than the second aeration unit in the bioreactor tank 1, while the third aeration unit is disposed at a position more distant from the inlet than the second aeration unit in the bioreactor tank 1.

The water treatment apparatus according to the first embodiment also includes aeration rate calculation units 70 (i.e., a first aeration rate calculation unit 71, a second aeration rate calculation unit 72, and a third aeration rate calculation unit 73), which individually control aeration rates of the respective aeration units, and air supply units 40 (i.e., a first air supply unit 41, a second air supply unit 42, and a third air supply unit 43), which supply air to the respective aeration units 30 at the respective aeration rates calculated by the respective aeration rate calculation units 70.

[0013] An influent load measurement unit 5, which measures an influent load of the treatment target water flowing into the bioreactor tank 1, is fitted to the pipe 103, or installed to a water conduit other than the pipe, to measure the influent load of the treatment target water before the treatment target water flows into the bioreactor tank 1. The influent load measurement unit 5 includes at least one or more measurement devices selected from a flowmeter and a pollutant concentration meter (i.e., an ammonia nitrogen concentration meter, a total nitrogen concentration meter, a biochemical oxygen demand (BOD) meter, a chemical oxygen demand (COD) meter, etc.). In a

case in which a flowmeter and a pollutant concentration meter are both used, the influent load may be calculated as a product of the flow rate of the treatment target water flowing into the bioreactor tank 1 and an influent pollutant concentration. Moreover, in a treatment plant having no flowmeter, the opening degree of a gate of an inlet conduit or the like may be used as an alternative to a flowmeter. Furthermore, a water temperature meter may also be installed, in addition to a flowmeter and/or a pollutant concentration meter, to take into account seasonal or other factors. The first embodiment assumes that the influent load is calculated as a product of the flow rate of the treatment target water flowing into the bioreactor tank 1 and the influent pollutant concentration.

The first aeration rate calculation unit 71, the second aeration rate calculation unit 72, and the third aeration rate calculation unit 73 calculate the respective aeration rates of air to be supplied to the respective aeration units based on a value of the influent load input via a signal line 5a, and send the respective aeration rates calculated, to the first air supply unit 41, to the second air supply unit 42, and to the third air supply unit 43, respectively, via signal lines 71a, 72a, and 73a. The first air supply unit 41, the second air supply unit 42, and the third air supply unit 43 supply air, according to the respective aeration rates transmitted, to the first aeration unit 31, to the second aeration unit 32, and to the third aeration unit 33 in the bioreactor tank 1 through pipes 41a, 42a, and 43a. In the bioreactor tank 1, the treatment target water flowed in through the pipe 103 is mixed and stirred with the activated sludge and with air supplied from the first aeration unit 31, from the second aeration unit 32, and from the third aeration unit 33 to

biologically oxidize and decompose pollution matter in the water for purification.

[0014] A water treatment method according to the first embodiment will next be described.

The influent load of the treatment target water flowing into the bioreactor tank 1 is measured by the influent load measurement unit 5, and the result is fed to the first aeration rate calculation unit 71, to the second aeration rate calculation unit 72, and to the third aeration rate calculation unit 73 via the signal line 5a. The first aeration rate calculation unit 71, the second aeration rate calculation unit 72, and the third aeration rate calculation unit 73 calculate, based on the influent load, setting values of the aeration rate of air to be supplied from the first aeration unit 31, from the second aeration unit 32, and from the third aeration unit 33.

Each of the aeration rate calculation units stores a coefficient predetermined for the corresponding aeration unit connected to that aeration rate calculation unit, and calculates the sum of (a) and (b) described below based on the influent load fed via the signal line 5a.

(a) A value calculated by multiplication of the influent load of the treatment target water flowing into the bioreactor tank 1 measured by the influent load measurement unit 5, by a first coefficient predetermined for that aeration unit

(b) Aeration unit constant

Feeding of the setting values of the aeration rate calculated as described above to the respective aeration units connected to the respective aeration rate calculation units, causes air to be supplied at the respective aeration rates from the respective aeration units to the bioreactor tank.

[0015] In this regard, the first coefficient is an optimum value obtained from simulation or from an analysis result of actual plant data to enable an optimum aeration rate to be obtained to let the aeration rate to quickly follow a variation in the influent load flowing into the bioreactor tank 1. Thus, different optimum values are set depending on the positions of, or on the number of, the aeration units.

For example, in a case in which the influent load measurement unit 5 includes a flowmeter and an ammonia nitrogen concentration meter, the aeration rate calculation unit 71 calculates a setting value G_1 [Nm^3/hr] of the aeration rate of air to be supplied from the first aeration unit 31 using Equation (1).

[0016]

[Formula 1]

$$G_1 = k_{11} \cdot S_{IN} \cdot Q_{IN} + k_{13} \quad \ldots (1)$$

[0017] Here, S_{IN} is an influent pollutant concentration, and is an ammonia nitrogen concentration measurement value [unit: mg/L] of the treatment target water flowing into the bioreactor tank. Q_{IN} is a flow rate measurement value [unit: m^3/hr] of the treatment target water flowing into the bioreactor tank. The factor k_{11} is the first coefficient for the first aeration unit 31, and k_{13} is the aeration unit constant for the aeration rate calculation unit 71.

Similarly, the aeration rate calculation units 72 and 73 calculate respective setting values G2 and G3 [Nm3/hr], the respective aeration rates of the second aeration unit 32 and 33 using Equations (2) and (3).

[0018]

[Formula 2]

$$G_2 = k_{21} \cdot S_{IN} \cdot Q_{IN} + k_{23} \quad \ldots (2)$$

[0019]

[Formula 3]

$$G_3 = k_{31} \cdot S_{IN} \cdot Q_{IN} + k_{33} \quad \ldots (3)$$

[0020] Here, k_{21} is the first coefficient for the second aeration unit 32, and k_{23} is the aeration unit constant for the second aeration unit 32. The factor k_{31} is the first coefficient for the third aeration unit 33, and k_{33} is the aeration unit constant for the third aeration unit 33.

In Equations (1), (2), and (3), the first coefficient for each of the aeration units is, as described above, an optimum value obtained from simulation or from an analysis result of actual plant data to enable an optimum amount of air supply to be obtained to let the aeration rate to quickly follow a variation in the influent load flowing into the bioreactor tank 1. Moreover, the values are set to allow the first coefficients k11, k21, and k31 to satisfy a relationship of $k11 \geq k21 \geq k31$. In addition, the aeration unit constants k13, k23, and k33 are each a constant to be set to provide fine adjustment of the aeration rate of each aeration unit, and for example, are each set to the minimum value of the aeration rate for that aeration unit.

This results in a higher aeration rate of aeration of an aeration unit closer to the inlet of the bioreactor tank 1, following a variation in the influent load of the treatment target water flowing into the bioreactor tank 1.

The setting values G_1, G_2, and G_3 of the aeration rate calculated using Equations (1), (2), and (3) are respectively fed to the first air supply unit 41, to the second air supply unit 42, and to the third air supply unit

43 via the signal lines 71a, 72a, and 73a.

The first air supply unit 41, the second air supply unit 42, and the third air supply unit 43 supply air at the respective set rates into the bioreactor tank 1 respectively via the pipes 41a, 42a, and 43a and respectively via the first aeration unit 31, the second aeration unit 32, and the third aeration unit 33.

[0021] Note that the foregoing description discloses that three aeration units are installed. Because two or more aeration units are desirably installed in the aerobic zone 102 in the bioreactor tank 1 along the flow direction of the treatment target water, a plurality of aeration units are installed. The aeration rate calculation unit is capable of calculating, for the multiple aeration units, an optimum aeration rate of air to be supplied from each of the aeration units using Equation (4).

[0022]

[Formula 4]

$$G_i = k_{i1} \cdot S_{IN} \cdot Q_{IN} + k_{i3} \quad \ldots (4)$$

[0023] Here, G_i is a setting value of the aeration rate for each of the aeration units. The parameter i=1, ···, n represents the number of each aeration unit, and represents the order of the aeration unit along the flow direction of the treatment target water in the bioreactor tank. The number n is a natural number greater than or equal to 2. S_{IN} represents an ammonia nitrogen concentration measurement value [unit: mg/L] of the treatment target water flowing into the bioreactor tank. Q_{IN} represents a flow rate measurement value [unit: m^3/hr]. The factor k_{i1} represents the first coefficient for that aeration unit, and k_{i3} represents the aeration unit constant for that aeration unit.

Note that Equation (4) provides calculation of the influent load of the treatment target water by a product of the flow rate of the treatment target water flowing into the bioreactor tank 1 and the influent pollutant concentration. However, in a case in which the flow rate of the treatment target water flowing into the bioreactor tank 1 is only measured, setting of, as the value of (a), a value calculated by multiplication of the flow rate of the treatment target water flowing into the bioreactor tank 1 by the first coefficient predetermined for that aeration unit, enables the setting value of the aeration rate to be calculated using Equation (4). Similarly, in a case in which the ammonia nitrogen concentration of the treatment target water flowing into the bioreactor tank 1 is only measured, setting of, as the value of (a), a value calculated by multiplication of the ammonia nitrogen concentration of the treatment target water flowing into the bioreactor tank 1 by the first coefficient predetermined for that aeration unit, enables the setting value of the aeration rate to be calculated using Equation (4).

[0024] In addition, although FIG. 1 illustrates the influent load measurement unit 5 as being connected to the pipe 103 provided on the inlet side of the bioreactor tank 1, the influent load measurement unit 5 may also be fitted at a fitting point 104 or at a fitting point 105 in the bioreactor tank 1. The fitting point 104 is positioned on the inlet side inside the bioreactor tank 1, in the anaerobic zone. The fitting point 105 is positioned at a position where the first aeration unit 31, i.e., the one closest to the inlet in the bioreactor tank 1, is disposed, that is, at a position on the entry side of the aerobic zone.

The measurement point of the influent load measurement unit 5 can be changed the fitting point to one of the pipe 103, the fitting point 104, and the fitting point 105 depending on the control purpose. In a treatment plant subjected to an influent load that varies significantly, connection of the influent load measurement unit 5 to the pipe 103 enables a variation in the influent load to be promptly detected. This improves followability of the aeration rate to the variation in the influent load, and can thus stabilize effluent water quality. Meanwhile, use of the fitting point 105 allows measurement of an actual influent load flowing into the aerobic zone, thereby enabling the aeration rate necessary for the treatment to be accurately computed, and enabling the total aeration rate to be thus minimized.

[0025] In addition to the treatment target water flowed in through the pipe 103, the bioreactor tank 1 also receives activated sludge that has returned from the settling tank 2 through the pipe d. When a need exists to take into account the effect of the returned activated sludge in addition to the effect of a variation in the influent load of the treatment target water, the influent load measurement unit 5 will be fitted at the fitting point 104 near the entry of the bioreactor tank 1. This will achieve measurement of the actual influent load flowing into the bioreactor tank 1, thereby enabling a variation in the influent load to also be quickly responded to while taking into account the effect of the returned sludge. This can provide a proper air supply, and can further reduce the aeration rate as compared to when measurement is performed at the pipe 103.

Note that when the influent load measurement unit 5 is installed at the fitting point 104, it leads to calculating

the aeration rate of each aeration unit based on the influent load of the treatment target water before passage through the anaerobic zone, which produces a time lag in controlling of aeration rate. Such time lag can be eliminated for further reduction in the aeration rate by installing the influent load measurement unit 5 at the fitting point 105, which is positioned at the entry of the aerobic zone where the activated sludge is about to be mixed with air in the bioreactor tank 1.

[0026] Moreover, FIG. 1 illustrates a case in which the anaerobic zone and the aerobic zone, in which activated sludge and air are mixed together, are provided in a single bioreactor tank. However, a similar advantage will also be achieved in a configuration in which the anaerobic zone and the aerobic zone are formed in different water tanks, that is, separated in the form of tanks which are an anaerobic tank and an aerobic tank. In this case, multiple aeration units are installed along the flow direction of the treatment target water in the aerobic tank, and the aeration rate calculation units and the air supply units that supply air to the respective aeration units control the aeration rates of the respective aeration units individually. Specifically, a higher aeration rate is used for an aeration unit closer to the inlet and a lower aeration rate is set for the supply from an aeration unit closer to the outlet in the bioreactor tank, based on the influent load of the treatment target water.

Although FIG. 1 illustrates a configuration in which only the anaerobic zone precedes the aerobic zone, the configuration may also include two or more zones involving no aeration being provided upstream of the aerobic zone, a typical example of which is an anaerobic-anoxic-oxic method (A2O method), which is a biological treatment for

simultaneously removing phosphorus and nitrogen. In this case, a similar advantage will be achieved by positioning the fitting point 104 on the inlet side inside the bioreactor tank 1 and positioning the fitting point 105 on the entry side of the aerobic zone.

[0027] The water treatment apparatus and the water treatment method according to the first embodiment each set the amount of air to be supplied into the bioreactor tank 1 based on the influent load of the treatment target water flowing or flowed into the bioreactor tank 1, thereby improving followability of the aeration rate to an influent load variation. This enables the aeration rate to be promptly controlled based on the influent load variation, and can thus reduce or prevent a variation in effluent water quality. Setting a higher aeration rate for an aeration unit closer to the inlet of the bioreactor tank 1, can reduce or prevent a variation in water quality in an upstream portion of the bioreactor tank, which is more susceptible to a variation in the influent load. Moreover, measurement of the influent load at a fitting point inside the bioreactor tank allows the actual influent load to be measured, thereby enabling the aeration rate necessary for the treatment to be suitably calculated, and enabling the total aeration rate to be thus reduced.

[0028] Second Embodiment.

A biological water treatment apparatus according to a second embodiment of the present invention will now be described with reference to FIG. 2. FIG. 2 is a configuration diagram of a biological water treatment apparatus. In the second embodiment, as a measurement unit for performing a measurement on the treatment target water, an effluent pollutant concentration measurement unit is installed on the outlet side instead of the influent load

measurement unit installed on the inlet side, of the water treatment apparatus according to the first embodiment. Note that, in the second embodiment, elements identical or equivalent to the corresponding elements in the first embodiment are designated by like reference characters, and duplicate description thereof will be omitted.

An effluent pollutant concentration measurement unit 6, which measures the pollutant concentration of effluent water that is to be drained out of the bioreactor tank 1, is fitted to the pipe 106 on the outlet side outside the bioreactor tank, or installed to a water conduit other than the pipe, to measure the effluent pollutant concentration of the treatment target water flowed out of the bioreactor tank. The effluent pollutant concentration measurement unit 6 includes an instrument for measuring the pollutant that is a target of water quality management in the water treatment. Examples of the instrument include an ammonia nitrogen concentration meter, a total nitrogen concentration meter, a BOD meter, and a COD meter. In addition, a water temperature meter may also be installed, in addition to the pollutant concentration meter, to take into account seasonal or other factors. The value of the effluent pollutant concentration is sent to the first aeration rate calculation unit 71, to the second aeration rate calculation unit 72, and to the third aeration rate calculation unit 73 via a signal line 6a.

A fitting point 107 is a possible fitting point of the effluent pollutant concentration measurement unit 6, alternative to the pipe 106, and is positioned on the outlet side inside the bioreactor tank. The effluent pollutant concentration measurement unit 6 may also be fitted at the fitting point 107.

[0029] A water treatment method according to the second

embodiment will next be described.

FIG. 3 is a configuration diagram of the aeration rate calculation unit 71 according to the second embodiment. The aeration rate calculation unit 71 includes an effluent pollutant concentration difference calculation unit 8, a proportional term calculation unit 9, an integral term calculation unit 10, a derivative term calculation unit 11, a target aeration rate calculation unit 12, and signal lines connecting these calculation units to one another. Referring to FIG. 3, a method for calculating an aeration rate will be described that is performed in the first aeration rate calculation unit 71, in the second aeration rate calculation unit 72, and in the third aeration rate calculation unit 73. Note that although FIG. 3 illustrates the aeration rate calculation unit 71, the aeration rate calculation units 72 and 73 are similarly configured.

The effluent pollutant concentration difference calculation unit 8 calculates an effluent pollutant concentration difference based on the effluent pollutant concentration sent via the signal line 6a and on a pollutant concentration target value of the effluent water.

On the basis of the effluent pollutant concentration difference sent from the effluent pollutant concentration difference calculation unit 8 via signal lines 8a, 8b, and 8c, the proportional term calculation unit 9 calculates an amount G_P of proportional control (P-control), the integral term calculation unit 10 calculates an amount G_I of integral control (I-control), and the derivative term calculation unit 11 calculates an amount G_D of derivative control (D-control). The values G_P, G_I, and G_D are respectively calculated using Equation (5-1), Equation (5-2), and Equation (5-3).

[0030]

[Formula 5-1]

$$G_P = K_P \cdot (S_{OUT} - S_0) \quad \ldots (5\text{-}1)$$

[0031]

[Formula 5-2]

$$G_I = K_P / T_I \cdot \int (S_{OUT} - S_0) dt \quad \ldots (5\text{-}2)$$

[0032]

[Formula 5-3]

$$G_D = K_P \cdot T_D \cdot d(S_{OUT} - S_0) / dt \quad \ldots (5\text{-}3)$$

[0033] Here, S_{OUT} is the effluent pollutant concentration, and is an ammonia nitrogen concentration measurement value [unit: mg/L] of the treatment target water flowed out of the bioreactor tank. S_0 is the pollutant concentration target value of the effluent water, and is a target value [unit: mg/L] of the ammonia nitrogen concentration of the treatment target water flowed out of the bioreactor tank. K_P is the proportional gain, T_I is the integration time, and T_D is the derivative time.

The target aeration rate calculation unit 12 calculates the setting value of the aeration rate of air to be supplied to the first aeration unit 31 based on the amount of proportional control sent via a signal line 9a, on the amount of integral control sent via a signal line 10a, and on the amount of derivative control sent via a signal line 11a. The setting value of the aeration rate calculated is sent to the air supply unit 41 via the signal line 71a.

Each of the aeration rate calculation units stores a second coefficient and the aeration unit constant k_{i3} predetermined for the aeration unit connected to that aeration rate calculation unit, and the target aeration

rate calculation unit 12 calculates the sum of (a) and (b) described below based on the values G_P, G_I, and G_D fed via the signal lines 9a, 10a, and 11a. The aeration rate is calculated using Equation (6).

(a) A value calculated by multiplication of a sum ($G_P+G_I+G_D$) by the second coefficient predetermined for that aeration unit

(b) Aeration unit constant

[0034]

[Formula 6]

$$G_i = k_{i2} \cdot (G_P + G_I + G_D) + k_{i3} \quad \ldots (6)$$

[0035] Here, G_i is a setting value of the aeration rate of air to be supplied to each of the aeration units. The parameter i=1, ···, n represents the number of each aeration unit, and represents the order of the aeration unit along the flow direction of the treatment target water in the bioreactor tank. The number n is a natural number greater than or equal to 2. G_P, G_I, and G_D are, respectively, the amount of proportional control, the amount of integral control, and the amount of derivative control, each calculated from the effluent pollutant concentration difference based on the effluent pollutant concentration measured and on the pollutant concentration target value of the effluent water. The factor k_{i2} is the second coefficient for that aeration unit. And k_{i3} is the aeration unit constant for the first aeration unit 31.

For example, the aeration rate calculation unit 71 calculates the setting value G_1 [Nm^3/hr] of the aeration rate of air to be supplied to the first aeration unit 31 using Equation (7).

[0036]

[Formula 7]

$$G_1 = k_{12} \cdot (G_P + G_I + G_D) + k_{13} \quad \ldots (7)$$

[0037] Here, k_{12} is the second coefficient for the first aeration unit 31, and k_{13} is the aeration unit constant for the first aeration unit 31.

Similarly, the aeration rate calculation units 72 and 73 calculate the respective setting values G_2 and G_3 [Nm^3/hr] of the aeration rate of the second aeration unit 32 and 33 respectively using Equations (8) and (9).

[0038]

[Formula 8]

$$G_2 = k_{22} \cdot (G_P + G_I + G_D) + k_{23} \quad \ldots (8)$$

[0039]

[Formula 9]

$$G_3 = k_{32} \cdot (G_P + G_I + G_D) + k_{33} \quad \ldots (9)$$

[0040] Here, k_{22} is the second coefficient for the second aeration unit 32, and k_{23} is the aeration unit constant for the second aeration unit 32; and k_{32} is the second coefficient for the third aeration unit 33, and k_{33} is the aeration unit constant for the third aeration unit 33.

In Equations (7), (8), and (9), the coefficient predetermined for each of the aeration units is an optimum value obtained from simulation or from an analysis result of actual plant data to enable an optimum aeration rate to be obtained to allow the pollutant concentration of the effluent water to be brought even closer to a predetermined target value of the pollutant concentration, and moreover, the values are set to allow the second coefficients k_{12}, k_{22}, and k_{32} to satisfy a relationship of $k_{12} \leq k_{22} \leq k_{32}$. The aeration unit constants k_{13}, k_{23}, and k_{33} are each a constant

to be set to provide fine adjustment of the aeration rate of each aeration unit, and for example, are each set to the minimum value of the aeration rate for that aeration unit.

[0041] Thus, the aeration rates are calculated to produce a greater amount of feedback control of aeration rate for an aeration unit closer to the outlet in the bioreactor tank.

The setting values G_1, G_2, and G_3 of the aeration rate for the respective aeration units calculated as described above are respectively sent to the first air supply unit 41, to the second air supply unit 42, and to the third air supply unit 43 via the signal lines 71a, 72a, and 73a.

Next, the first air supply unit 41, the second air supply unit 42, and the third air supply unit 43 supply air to the bioreactor tank 1 at the respective aeration rates that have been set respectively via the pipes 41a, 42a, and 43a and respectively via the first aeration unit 31, the second aeration unit 32, and the third aeration unit 33. Note that the foregoing description assumes that three aeration units are installed. Because two or more aeration units are desirably installed in the aerobic zone 102 in the bioreactor tank 1 along the flow direction of the treatment target water, a plurality of aeration units are installed. The aeration rate calculation unit is capable of calculating, for the multiple aeration units, an optimum aeration rate of air to be supplied from each of the aeration units using Equation (6).

[0042] Although FIG. 2 illustrates the effluent pollutant concentration measurement unit 6 as being connected to the pipe 106 provided on the outlet side outside the bioreactor tank, the measurement point of the effluent pollutant concentration measurement unit 6 can be changed the fitting point to one of the pipe 106 and the

fitting point 107 positioned on the outlet side inside the bioreactor tank depending on the control purpose. Use of a point in the pipe 106 allows water quality of the effluent water flowed out of the bioreactor tank to be directly measured, thereby providing computation of the aeration rate necessary to control the effluent water quality to the target value. When emphasis is placed on a reduction in the aeration rate to avoid excessive aeration that will provide a higher level of water quality than required, the effluent pollutant concentration measurement unit 6 can be installed to the pipe 106.

Meanwhile, when a need exists for reliably preventing the water quality of the effluent water from exceeding a management value, the effluent pollutant concentration measurement unit 6 is installed at the fitting point 107, upstream of the outlet at the downstream end in the bioreactor tank 1. Use of the fitting point 107 allows water treatment to be continued until the treatment target water completely flows out even after the effluent pollutant concentration measurement unit 6 measures water quality, thereby enabling the effluent water quality to be reliably controlled to a level of, or less than, the management value.

This means that the ammonia concentration is accordingly reduced to the target value before complete termination of the biological treatment reaction in the reactor tank, thereby making it likely that the total aeration rate will be higher than when the effluent pollutant concentration measurement unit 6 is installed to the pipe 106. This enables the water quality of the eventual effluent water to be kept at an appropriate level owing to treatment in a zone downstream of the fitting point 107 even when the pollutant concentration measured by

the effluent pollutant concentration measurement unit 6 reaches or exceeds the target value due to delay in the controlling of aeration rate.

[0043] According to the water treatment apparatus and the water treatment method according to the second embodiment, the values of the aeration rate of air to be supplied into the bioreactor tank 1 are set based on the difference between the pollutant concentration and the target value of the pollutant concentration, of the treatment target water flowing or flowed out of the bioreactor tank 1. This enables the pollutant concentration of the treatment target water flowed out after the biological reaction treatment to be brought closer to the target value.

In addition, the aeration rates are calculated to cause an aeration unit disposed closer to the outlet of the bioreactor tank 1 to provide more stringent PID control to control the effluent pollutant concentration of the treatment target water to a target value, thereby enabling the pollutant concentration of the effluent water to be more finely controlled toward the target value, and thus enabling the effluent water quality to be stably maintained.

[0044] Third Embodiment.

A biological water treatment apparatus according to a third embodiment of the present invention will now be described with reference to FIG. 4. FIG. 4 is a configuration diagram of a biological water treatment apparatus.

In the third embodiment, the influent load measurement unit 5 fitted on the inlet side of the bioreactor tank and the effluent pollutant concentration measurement unit 6 fitted on the outlet side of the bioreactor tank are both installed. The value of the influent load is sent to the

first aeration rate calculation unit 71, to the second aeration rate calculation unit 72, and to the third aeration rate calculation unit 73 via the signal line 5a, and the effluent pollutant concentration is also sent to the first aeration rate calculation unit 71, to the second aeration rate calculation unit 72, and to the third aeration rate calculation unit 73 via the signal line 6a.

Note that, in the third embodiment, elements identical or equivalent to the corresponding elements in the first embodiment and in the second embodiment are designated by like reference characters, and duplicate description thereof will be omitted.

[0045] FIG. 5 is a configuration diagram of an aeration rate calculation unit according to the third embodiment. The aeration rate calculation unit 71 includes the effluent pollutant concentration difference calculation unit 8, the proportional term calculation unit 9, the integral term calculation unit 10, the derivative term calculation unit 11, the target aeration rate calculation unit 12, and signal lines connecting these calculation units to one another. In addition, the configuration differs from the configuration of FIG. 3 in that the target aeration calculation unit 12 is also connected with the signal line 5a that transmits the measurement result from the influent load measurement unit 5. Referring to FIG. 5, a method for calculating the aeration rate will be described that is performed in the first aeration rate calculation unit 71, in the second aeration rate calculation unit 72, and in the third aeration rate calculation unit 73. Note that although FIG. 5 illustrates the aeration rate calculation unit 71, the aeration rate calculation units 72 and 73 are similarly configured. In addition, the effluent pollutant concentration difference calculation unit 8, the

proportional term calculation unit 9, the integral term calculation unit 10, the derivative term calculation unit 11, and the signal lines 8a, 8b, and 8c are identical or equivalent to the corresponding elements illustrated in FIG. 3.

The target aeration rate calculation unit 12 calculates the setting value of the aeration rate of air to be supplied from the first aeration unit 31 based on the value of the influent load sent via the signal line 5a, on proportional term information sent via the signal line 9a, on integral term information sent via the signal line 10a, and on derivative term information sent via the signal line 11a.

[0046] Each of the aeration rate calculation units stores the first coefficient k_{i1}, the second coefficient k_{i2}, and the aeration unit constant k_{i3} predetermined for the corresponding one of the aeration units, and calculates the sum of (a), (b), and (c) described below based on the value of the influent load of the treatment target water flowing into the bioreactor tank 1 sent via the signal line 5a, and on the amount G_P of proportional control, on the amount G_I of integral control, and the amount G_D of derivative control sent via the signal lines 9a, 10a, and 11a.

(a) An inlet-side controlled aeration rate based on a value calculated by multiplication of the influent load of the treatment target water flowing into the bioreactor tank 1 measured by the influent load measurement unit 5, by the first coefficient predetermined for that aeration unit

(b) An outlet-side controlled aeration rate based on a value calculated by multiplication of a sum ($G_P+G_I+G_D$) by the second coefficient predetermined for that aeration unit

(c) Aeration unit constant

By sending the setting values of the aeration rate

calculated as described above to the respective aeration units connected to the respective aeration rate calculation units, air is supplied at the respective aeration rates from the respective aeration units to the bioreactor tank.

[0047] Note that the first coefficient, the second coefficient, and the constant described above are each an optimum value obtained from simulation or from an analysis result of actual plant data so that an optimum aeration rate, which allows the pollutant concentration of the effluent water that are drained out of the bioreactor tank 1 to be brought even closer to a predetermined target value of the pollutant concentration, can be obtained. Thus, different values are set depending on the positions of, or on the number of, the aeration units. The first coefficient is set to a higher value for a position closer to the inlet of the bioreactor tank, while the second coefficient is set to a higher value for a position closer to the outlet of the bioreactor tank.

The aeration rate calculation unit adds together a value, calculated based on the influent load of the treatment target water, that produces a higher aeration rate for an aeration unit closer to the inlet in the bioreactor tank, and a value, calculated based on the effluent pollutant concentration, that produces a greater amount of feedback control of aeration rate for an aeration unit closer to the outlet in the bioreactor tank, thus to calculate each aeration rate. The setting value G_i [Nm^3/hr] of the aeration rate for each of the aeration units is calculated using Equation (10).

[0048]

[Formula 10]

$$G_i = k_{i1} \cdot S_{IN} \cdot Q_{IN} + k_{i2} \cdot (G_P + G_I + G_D) + k_{i3} \quad \ldots (10)$$

[0049] Here, G_i is a setting value of the aeration rate of air to be supplied to each of the aeration units. The parameter i=1, ···, n represents the number of each aeration unit, and is the order of the aeration unit along the flow direction of the treatment target water in the bioreactor tank. The number n is a natural number greater than or equal to 2. S_{IN} is the influent pollutant concentration, and is the ammonia nitrogen concentration measurement value [unit: mg/L] of the treatment target water flowing into the bioreactor tank. Q_{IN} is the flow rate measurement value [unit: m^3/hr] of the treatment target water flowing into the bioreactor tank. G_P, G_I, and G_D are, respectively, the amount of proportional control, the amount of integral control, and the amount of derivative control, each calculated from the effluent pollutant concentration difference based on the effluent pollutant concentration measured and on the pollutant concentration target value of the effluent water. The factor k_{i1} is the first coefficient for that aeration unit, k_{i2} is the second coefficient for that aeration unit, and k_{i3} is the aeration unit constant for the first aeration unit 31.

For example, in the case in which the influent load measurement unit 5 includes a flowmeter and an ammonia nitrogen concentration meter, and the effluent pollutant concentration measurement unit 6 includes an ammonia nitrogen concentration meter, the aeration rate calculation unit 71 calculates the setting value G_1 [Nm^3/hr] of the aeration rate of air to be supplied from the first aeration unit 31 using Equation (11).

[0050]

[Formula 11]

$$G_1 = k_{11} \cdot S_{IN} \cdot Q_{IN} + k_{12} \cdot (G_P + G_I + G_D) + k_{13} \quad \ldots (11)$$

[0051] Here, k_{11} is the first coefficient for the first aeration unit 31. k_{12} is the second coefficient for the first aeration unit 31. k_{13} is the aeration unit constant for the first aeration unit 31.

Similarly, the aeration rate calculation units 72 and 73 calculate the respective setting values G_2 and G_3 [Nm^3/hr] of the aeration rate of the second aeration unit 32 and 33 using Equations (11) and (12).

[0052]

[Formula 12]

$$G_2 = k_{21} \cdot S_{IN} \cdot Q_{IN} + k_{22} \cdot (G_P + G_I + G_D) + k_{23} \quad \ldots (12)$$

[0053]

[Formula 13]

$$G_3 = k_{31} \cdot S_{IN} \cdot Q_{IN} + k_{32} \cdot (G_P + G_I + G_D) + k_{33} \quad \ldots (13)$$

[0054] Here, k_{21} is the first coefficient for the second aeration unit 32, k_{22} is the second coefficient for the second aeration unit 32, and k_{23} is the aeration unit constant for the second aeration unit 32.

In addition, k_{31} is the first coefficient for the third aeration unit 33, k_{32} is the second coefficient for the third aeration unit 33, and k_{33} is the aeration unit constant for the third aeration unit 33.

In Equations (11), (12), and (13), the first coefficient and the second coefficient predetermined for each of the aeration units are, as described above, each an optimum value obtained from simulation or from an analysis result of actual plant data so as to obtain an optimum aeration rate allowing the pollutant concentration of the effluent water to be brought even closer to a predetermined target value of the pollutant concentration. Moreover, the

values are set to allow the first coefficients k_{11}, k_{21}, and k_{31} to satisfy a relationship of $k_{11} \geq k_{21} \geq k_{31}$, and to allow the second coefficients k_{12}, k_{22}, and k_{32} to satisfy a relationship of $k_{12} \leq k_{22} \leq k_{32}$. In addition, similarly to the first embodiment and the second embodiment, each of the aeration unit constants k_{13}, k_{23}, and k_{33} is set to the minimum value of the aeration rate for that aeration unit to provide fine adjustment of the aeration rate of each of the aeration units.

Thus, the aeration rate calculation unit adds together the value, calculated based on the influent load of the treatment target water, that produces a higher aeration rate for an aeration unit closer to the inlet in the bioreactor tank, and the value, calculated based on the effluent pollutant concentration, that produces a greater amount of feedback control of aeration rate for an aeration unit closer to the outlet in the bioreactor tank, thus to calculate each aeration rate.

Note that the foregoing description assumes that three aeration units are installed. Because two or more aeration units are desirably installed in the aerobic zone 102 in the bioreactor tank 1 along the flow direction of the treatment target water, a plurality of aeration units are installed. The aeration rate calculation unit is capable of calculating, for the multiple aeration units, an optimum aeration rate of air to be supplied from each of the aeration units using Equation (10).

In addition, Equation (10) provides calculation of the inlet-side controlled aeration rate based on a variation in the influent load of the treatment target water by a product of the flow rate of the treatment target water flowing into the bioreactor tank 1 and the influent pollutant concentration. However, in a case in which the

flow rate of the treatment target water flowing into the bioreactor tank 1 is only measured, setting of, as the value of (a), a value calculated by multiplication of the flow rate of the treatment target water flowing into the bioreactor tank 1 by the first coefficient predetermined for that aeration unit, enables the setting value of the aeration rate to be calculated using Equation (4). Similarly, in a case in which the ammonia nitrogen concentration of the treatment target water flowing into the bioreactor tank 1 is only measured, setting of, as the value of (a), a value calculated by multiplication of the ammonia nitrogen concentration of the treatment target water flowing into the bioreactor tank 1 by the first coefficient predetermined for that aeration unit, enables the setting value of the aeration rate to be calculated using Equation (4).

[0055] Although FIG. 4 illustrates the influent load measurement unit 5 as being installed to the pipe 103 or installed to a water conduit other than the pipe to measure the influent load of the treatment target water before flowing into the bioreactor tank 1, the influent load measurement unit 5 may also be fitted, similarly to the first embodiment, at the fitting point 104 or at the fitting point 105 in the bioreactor tank 1. The fitting point 104 is positioned on the inlet side in the bioreactor tank 1, in the anaerobic zone. The fitting point 105 is positioned at a position where the first aeration unit 31, i.e., the one closest to the inlet in the bioreactor tank 1, is disposed, that is, at a position on the entry side of the aerobic zone.

The measurement point of the influent load measurement unit 5 can be changed the fitting point to one of the pipe 103, the fitting point 104, and the fitting point 105

depending on the control purpose. In a treatment plant subjected to an influent load that varies significantly, connection of the influent load measurement unit 5 to the pipe 103 enables a variation in the influent load to be promptly detected. This improves followability of the aeration rate to the variation in the influent load, and can thus stabilize effluent water quality. Meanwhile, use of the fitting point 105 allows measurement of an actual influent load flowing into the aerobic zone, thereby enabling the aeration rate necessary for the treatment to be accurately computed, and enabling the total aeration rate to be thus minimized.

[0056] In addition to the treatment target water flowed in through the pipe 103, the bioreactor tank 1 also receives activated sludge that has returned from the settling tank 2 through the pipe d. When a need exists to also take into account the effect of the return activated sludge in addition to the effect of a variation in the influent load of the treatment target water, the influent load measurement unit 5 is fitted at the fitting point 104 near the entry of the bioreactor tank 1. This achieves measurement of the actual influent load flowing into the bioreactor tank 1, thereby enabling a variation in the influent load to also be quickly responded to while taking into account the effect of the returned sludge. Due to the position also enabling prompt response to a variation in the influent load, this can provide a proper air supply, and can further reduce the aeration rate as compared to when measurement is performed at the pipe 103.

Note that installation of the influent load measurement unit 5 at the fitting point 104 causes the aeration rate of each of the first aeration unit 31, the second aeration unit 32, and the third aeration unit 33 to be calculated

based on the influent load of the treatment target water before passage through the anaerobic zone, which produces a time lag in controlling of aeration rate. Such time lag can be eliminated for further reduction in the aeration rate by installing the influent load measurement unit 5 at the fitting point 105, positioned at the entry of the aerobic zone where the activated sludge is about to be mixed with air in the bioreactor tank 1.

Although FIG. 4 illustrates a configuration in which only the anaerobic zone precedes the aerobic zone, the configuration may also include two or more zones involving no aeration being provided upstream of the aerobic zone, a typical example of which is an anaerobic-anoxic-oxic method (A2O method), which is a biological treatment for simultaneously removing phosphorus and nitrogen. In this case, a similar advantage can be achieved by positioning the fitting point 104 on the inlet side inside the bioreactor tank 1 and positioning the fitting point 105 on the entry side of the aerobic zone.

[0057] Moreover, FIG. 4 illustrates the effluent pollutant concentration measurement unit 6 as being installed to the pipe 106 provided on the outlet side outside the bioreactor tank or installed to a water conduit other than the pipe, to measure the effluent pollutant concentration of the treatment target water flowed out of the bioreactor tank 1. However, the measurement point of the effluent pollutant concentration measurement unit 6 can be changed the fitting point to one of the pipe 106 and the fitting point 107 depending on the control purpose similarly to the second embodiment.

Use of a point in the pipe 106 allows water quality of the effluent water flowed out of the bioreactor tank to be directly measured, thereby providing computation of the

aeration rate necessary to control the effluent water quality to the target value. When emphasis is placed on a reduction in the aeration rate to avoid excessive aeration that provides a higher level of water quality than required, the effluent pollutant concentration measurement unit 6 can be installed to the pipe 106.

[0058] Meanwhile, when a need exists for reliably preventing the water quality of the effluent water from exceeding a management value, the effluent pollutant concentration measurement unit 6 is installed at the fitting point 107, upstream of the outlet at the downstream end in the bioreactor tank 1. Use of the fitting point 107 allows water treatment to be continued until the treatment target water completely flows out even after the effluent pollutant concentration measurement unit 6 measures water quality, thereby enabling the effluent water quality to be reliably controlled to a level of, or less than, the management value.

This means that the ammonia concentration is accordingly reduced to the target value before complete termination of the biological treatment reaction in the reactor tank, thereby making it likely that the total aeration rate will be higher than when the effluent pollutant concentration measurement unit 6 is installed to the pipe 106. This enables the water quality of the eventual effluent water to be kept at an appropriate level owing to treatment in a zone downstream of the fitting point 107 even when the pollutant concentration measured by the effluent pollutant concentration measurement unit 6 reaches or exceeds the target value due to delay in the controlling of aeration rate.

[0059] The water treatment apparatus and the water treatment method according to the third embodiment each set

the values of the aeration rate of air to be supplied into the bioreactor tank 1 taking into account both the influent load of the treatment target water flowing or flowed into the bioreactor tank 1 and the difference between the pollutant concentration of the effluent water being currently drained out of the bioreactor tank 1 and the target value thereof. This enables the pollutant concentration of the effluent water to be brought even closer to the target value, and thus enables the water quality to be more finely controlled.

[0060] In addition, computation of the aeration rate is subjected to a condition of magnitude relationship among the coefficients each predetermined for the first aeration unit 31, for the second aeration unit 32, and for the third aeration unit 33 respectively connected to the first air supply unit 41, to the second air supply unit 42, and to the third air supply unit 43 based on the positions thereof in the bioreactor tank 1. This causes air to be supplied from an aeration unit closer to the inflow port of the bioreactor tank 1 depending primarily on the influent load of the treatment target water flowing or flowed into the bioreactor tank 1, and from an aeration unit closer to the outflow port of the bioreactor tank 1 depending primarily on the difference between the pollutant concentration of the effluent water and the target value thereof. This can provide suitable air supply at each particular point in the bioreactor tank 1 even under variation in the influent load, and enables the pollutant concentration of the effluent water that is to be drained to be brought even closer to the target value. Moreover, efficient water quality control can be provided using proper amounts of air supply.

Reference Signs List

[0061] 1 bioreactor tank; 5 influent load measurement unit; 6 effluent pollutant concentration measurement unit; 8 effluent pollutant concentration difference calculation unit; 9 proportional term calculation unit; 10 integral term calculation unit; 11 derivative term calculation unit; 12 target aeration rate calculation unit; 30 aeration unit; 31 first aeration unit; 32 second aeration unit; 33 third aeration unit; 40 air supply unit; 41 first air supply unit; 42 second air supply unit; 43 third air supply unit; 70 aeration rate calculation unit; 71 first aeration rate calculation unit; 72 second aeration rate calculation unit; 73 third aeration rate calculation unit; 100 partition plate; 101 anaerobic zone; 102 aerobic zone; 103, 106, 108 pipe; 104, 105, 107 fitting point.

CLAIMS

1. A water treatment apparatus that aerates, with air, treatment target water that flows into a bioreactor tank through an inlet, performs biological reaction treatment, and drains the treatment target water out of the bioreactor tank through a drain port, the water treatment apparatus comprising:

a first aeration unit and a second aeration unit to each aerate the treatment target water with the air; and

an aeration rate calculation unit to control an aeration rate of the first aeration unit and an aeration rate of the second aeration unit, wherein

the first aeration unit is disposed at a position less distant from the inlet than the second aeration unit in the bioreactor tank, and

the aeration rate calculation unit provides control to produce different aeration rates for the first aeration unit and the second aeration unit.

2. The water treatment apparatus according to claim 1, comprising:

a third aeration unit to aerate the treatment target water with the air, wherein

the third aeration unit is disposed at a position more distant from the inlet than the second aeration unit in the bioreactor tank, and

the aeration rate calculation unit provides control to produce different aeration rates for the first aeration unit, the second aeration unit, and the third aeration unit.

3. The water treatment apparatus according to claim 1 or 2, comprising:

an influent load measurement unit to measure an

influent load of the treatment target water, wherein

the aeration rate calculation unit provides control to produce the different aeration rates for the respective aeration units based on the influent load of the treatment target water.

4. The water treatment apparatus according to claim 1 or 2, comprising:

an effluent pollutant concentration measurement unit to measure an effluent pollutant concentration of the treatment target water, wherein

the aeration rate calculation unit provides feedback control to produce the different aeration rates for the respective aeration units based on the effluent pollutant concentration.

5. The water treatment apparatus according to claim 1 or 2, comprising:

an influent load measurement unit to measure an influent load of the treatment target water; and

an effluent pollutant concentration measurement unit to measure an effluent pollutant concentration of the treatment target water, wherein

the aeration rate calculation unit determines the aeration rate for each of the aeration units by adding together an inlet-side controlled aeration rate and an outlet-side controlled aeration rate, the inlet-side controlled aeration rate being calculated to produce different values for the aeration units based on the influent load of the treatment target water, the outlet-side controlled aeration rate being calculated to produce different values for the aeration units based on the effluent pollutant concentration.

6. The water treatment apparatus according to claim 3 or 5, wherein the influent load measurement unit measures an influent load of the treatment target water before the treatment target water flows into the bioreactor tank.

7. The water treatment apparatus according to claim 3 or 5, wherein the influent load measurement unit is installed at a position closer to the inlet in the bioreactor tank.

8. The water treatment apparatus according to claim 3 or 5, wherein the influent load measurement unit is installed at a position where one aeration unit that is closest to the inlet in the bioreactor tank is disposed, out of the plurality of aeration units.

9. The water treatment apparatus according to claim 4 or 5, wherein the effluent pollutant concentration measurement unit measures an effluent pollutant concentration of the treatment target water that flows out of the bioreactor tank.

10. The water treatment apparatus according to claim 4 or 5, wherein the effluent pollutant concentration measurement unit is installed in a portion closer to an outlet inside the bioreactor tank.

11. A water treatment method comprising:

a step of measuring an influent load of treatment target water that flows into a bioreactor tank;

a step of calculating, based on the influent load, an inlet-side controlled aeration rate of each of a plurality of aeration units disposed along a direction of flow of the

treatment target water in the bioreactor tank to produce different inlet-side controlled aeration rates for the respective aeration units; and

a step in which each of the aeration units supplied with air that corresponds to a corresponding one of the aeration rates aerates the treatment target water with the air.

12. A water treatment method comprising:

a step of measuring an effluent pollutant concentration of treatment target water that flows out of a bioreactor tank;

a step of calculating, based on the effluent pollutant concentration, an outlet-side controlled aeration rate of each of a plurality of aeration units disposed along a direction of flow of the treatment target water in the bioreactor tank to produce different outlet-side controlled aeration rates for the respective aeration units; and

a step in which each of the aeration units supplied with air that corresponds to a corresponding one of the aeration rates aerates the treatment target water with the air.

13. A water treatment method comprising:

a step of measuring an influent load of treatment target water that flows into a bioreactor tank;

a step of measuring an effluent pollutant concentration of the treatment target water that flows out of the bioreactor tank;

a step of calculating, based on the influent load, an inlet-side controlled aeration rate of each of a plurality of aeration units, which are disposed along a direction of flow of the treatment target water in the bioreactor tank,

to produce different inlet-side controlled aeration rates for the respective aeration units, and

a step of calculating, based on the effluent pollutant concentration, an outlet-side controlled aeration rates of each of the aeration units to produce different outlet-side controlled aeration rates for the respective aeration units;

a step of determining an aeration rate for each corresponding one of the aeration units by adding together the inlet-side controlled aeration rate and the outlet-side controlled aeration rate; and

a step in which each of the aeration units supplied with air that corresponds to a corresponding one of the aeration rates aerates the treatment target water with the air.

14. The water treatment method according to claim 12 or 13, wherein

the step of calculating an outlet-side controlled aeration rate includes,

calculating an amount of proportional control, an amount of integral control, and an amount of derivative control each based on an effluent pollutant concentration difference calculated from the effluent pollutant concentration and a pollutant concentration target value of effluent water, and adding together the amount of proportional control, the amount of integral control, and the amount of derivative control.