

WASTE WATER TREATMENT METHOD AND WASTE WATER TREATMENT SYSTEM

TECHNICAL FIELD

[0001]

The present invention relates to a waste water treatment method of industrial wastewater, domestic wastewater, human waste, and the like, and a waste water treatment system.

The present application is based on and claims the right of priority from PCT/JP2013/066393 filed June 13, 2013, and the content of which is incorporated herein by reference.

BACKGROUND ART

[0002]

In the related art, it is known that biological treatments are effective as waste water treatment methods of industrial wastewater, domestic wastewater, human waste, and the like. Amongst these, an activated sludge process is most widely adopted (for example, refer to Non-Patent Document 1).

An activated sludge process is a method that treats waste water by aerating waste water in an aeration tank (an aerobic tank), and degrading organic matter (hereinafter, referred to as “BOD”) in the waste water using the oxygen respiration of aerobic microbes in an activated sludge.

[0003]

In addition to BOD, there are cases in which nitrogen such as organic nitrogen (for example, proteins, amino acids, urea, and the like), ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen and phosphorus are contained in waste water, and there are also cases in which it is necessary to remove these substances.

As treatment methods of waste water that contains BOD, nitrogen and phosphorous, nitrification-denitrification processes, anaerobic-aerobic processes (AO processes), anaerobic-anoxic-oxic processes (A2O processes), anaerobic-nitrification and endogenous denitrification processes (AOAO processes), and the like, which are methods that treat waste water in tanks with different operating conditions of microbes with different kinds of metabolisms, are known (for example, Non-Patent Document 2).

In addition, as treatment methods of waste water that contains BOD, and nitrogen, methods that treat waste water in a single tank with microbes with different kinds of metabolisms by controlling a dissolved oxygen concentration to be less than or equal to 1 mg/L, are known (for example, refer to Patent Documents 1 and 2).

[0004]

In addition, as ability enhancing technologies of treatment tanks, biofilm treatment processes such as carrier-added activated sludge processes, contact oxidation processes, and rocking bed processes are known. Biofilm treatment processes achieve enhancements in treatment ability through increases in the number of microbes inside an aeration tank by attaching microbes inside the aeration tank to a man-made filter media (for example, a carrier, a filter bed, a rocking bed or the like).

[0005]

Given that, the molding of a structure (the formation of a biofilm) that is characterized by bacteria in an activated sludge producing extracellular polysaccharides (EPS) in water, and including other bacteria and microbes, is known (for example, refer to Non-Patent Document 3). An example of the features of a biofilm will be illustrated below.

(i) Since EPS in biofilms are produced by microbes, the composition thereof, that is, the physical and chemical properties vary greatly.

(ii) In biofilms, microbes exist at densities that are several orders of magnitude higher (exclusive colonies with high habitation densities are formed) than in the surrounding environment, and it is easy for homeostasis (an action that maintains the internal environment inside the microbes in a constant state) to be maintained.

(iii) The oxygen concentration and ion concentration inside a biofilm differs with distance from water channels, and distance from the biofilm surface, and an oxygen concentration gradient and an ion concentration gradient are formed in the order of μm . Therefore, a large variety of niches (ecological niches) are created, and habitat isolation of microbes with different metabolic systems (for example, aerobic microbes, anaerobic microbes and the like) can be found at a level in the order of μm .

(iv) Biofilms also have a shielding/protective function of microbes with respect to various stimuli such as increasing the drug resistance of the internal

microbes, and improving the protective performance from heavy metal and organic solvent toxins.

(v) Inside biofilms, many kinds of microbes mutually exchange metabolic products, energy and information, and it is possible to cope with a wide variety of environmental changes while creating functions that are not present in individual microbes (it is possible to metabolize substances that cannot be metabolized by a single kind of microbe).

(vi) The proliferation rate of microbes inside biofilms is lower than that of surface microbes.

(vii) For example, if bacteria are subjected to stress such as a nutrient (for example, nitrogen and phosphorous) deficient state, or an oxygen deficiency, the amount of production of EPS increases.

CITATION LIST

Non-Patent Literature(s)

[0006]

Non-Patent Document 1: "Improvement and Enhancement Technology for Activated Sludge Technique", November 1, 1979, Science and Technology Development Center, Chapter 1: Activated Sludge Technique Improvement Measures, Pages 1-1 to 1-3

Non-Patent Document 2: City Bureau of Ministry of Construction Sewer Section Editor "Sewer Facilities Planning and Design Guidelines, and Concluding Commentary 1994 Edition", October 25, 1994, Japan Sewage Works Association, Chapter 5: Water Treatment Facilities, Pages 126 to 139

Non-Patent Document 3: "Biofilm Manual - New microbes of the Environmental Century", October 17, 2005, Japanese Society of Microbial Ecology Biofilm Research Group, Chapter I: Biofilms as Habitat Locations of Microorganisms, Chapter I, Pages 1 to 10

Patent Literature(s)

[0007]

Patent Document 1: Japanese Unexamined Patent Application Publication No. S59-90696A

Patent Document 2: Japanese Unexamined Patent Application Publication No. 2011-5354A

SUMMARY OF INVENTION

Technical Problem

[0008]

However, in the case of the activated sludge process, normally, since operational control is performed such that a BOD volumetric load of the aeration tank is approximately from 0.3 to 0.8 kg-BOD/m³·d, and the dissolved oxygen concentration is approximately from 1 to 2 mg/L, the aeration tank volume is large, it is necessary to supply a large amount of air (oxygen), and therefore, the power consumption of a blower or the like is large. Additionally, in the activated sludge process, a large quantity of surplus sludge is created, and the treatment costs (dehydration costs, drying costs, industrial waste treatment costs, and the like) of the surplus sludge run to large amounts.

In addition, in the activated sludge process, small amounts of BOD are degraded as a result of the respiration (sulfur respiration) and fermentation of anaerobic microbes in anaerobic portions such as the interiors of flocs that are formed, and dead space which the stirring of the aeration tank does not reach. At this time, substances such as organic acids, alcohols, and hydrogen sulfide which cause bad odors are generated.

Furthermore, in the activated sludge process, in a case in which the dissolved oxygen concentration of the aeration tank is low as a result of sudden load fluctuations (rises in particular), BOD component changes in waste water and the like, there are cases in which bulking occurs. Once bulking occurs, it is difficult for the sludge to settle, and therefore, it is difficult to perform solid-liquid separation of treated water and the sludge in a sedimentation tank that is positioned downstream of the aeration tank.

[0009]

In a case in which waste water is treated using a nitrification-denitrification process, an AO process, an A2O process, and an AOA process, or the like, since the metabolisms (the respiration) of the microbes that treat the BOD, the nitrogen and the phosphorous, differ, an anaerobic tank, an anoxic tank and an aerobic tank are necessary as treatment tanks in order to treat all of these. Therefore, the installation area of the treatment tanks is large, and therefore, operational management is complicated.

In addition, in the biological treatment methods disclosed in Patent Documents 1 and 2 in which the dissolved oxygen concentration is less than or equal to 1 mg/L, it is easy for treatability to deteriorate as a result of small

changes in raw material water conditions and operating conditions, and therefore, treatability retention and operational continuance are problems. Furthermore, in the methods disclosed in Patent Documents 1 and 2, the treatment of BOD and nitrogen in a single tank is disclosed, but there is no disclosure relating to treatment of waste water in which the amount of nitrogen is small in comparison with BOD, or in which nitrogen is not contained. In addition, there is no disclosure relating to the simultaneous removal of BOD, nitrogen and phosphorous in a single tank in a case in which phosphorous is also contained.

In addition, biofilm treatment processes can enhance treatability by increasing the quantity of microbes inside a treatment tank by attaching microbes inside the treatment tank to a filter media (an immobilized bed, a fluid carrier, a rocking fiber filter or the like). However, even if microbes with different metabolisms are attached to a single filter media, if the treatment tank is aerobic, it is difficult to simultaneously enhance the actions of anaerobic microbes. Therefore, in a case of treating waste water in which BOD, nitrogen and phosphorous are contained, even if it is possible to reduce the volume of each treatment tank by adopting a biofilm treatment process, it is not possible to reduce the number of treatment tanks.

[0010]

In addition, water treatment technologies of the related art, among the abovementioned features of biofilms, the aggregation properties and high density maintenance properties of microbes and the like have been utilized in activated sludge processes and biofilm treatment processes, but there is not a water treatment technology that uses the symbiosis of microbes with different metabolisms.

[0011]

In light of the foregoing, an object of the present invention is to provide a waste water treatment method and a waste water treatment system that can simultaneously achieve the enhancement of treatment ability, reductions in the power consumption and amount of surplus sludge and suppressions in the bad odor generation and bulking in a case of treating waste water that contains BOD, and in which the continuance of stable operation and treatability retention are possible.

In addition, another object of the present invention is to provide a waste water treatment method and a waste water treatment system that can even

perform treatment in a single tank in a case of treating waste water that contains BOD, and contains either one or both of nitrogen and phosphorous.

Solution to Problem

[0012]

The present invention focuses on biofilms (colonies of microbes) that are configured by EPS that is produced in the microbes. In this instance, biofilms inside a biological treatment tank do not solely refer to biofilms that are formed on fixed surfaces such as treatment tank wall surfaces and portions with which water comes into contact, but also refers to biofilms that are generally formed in liquid inside a treatment tank, and the latter are in a dispersed suspended state inside a treatment tank.

The fact that microbes with different metabolic systems (for example, aerobic microbes, anaerobic microbes and the like) can live in symbiosis inside biofilms led to the idea that it is possible to simultaneously treat all of BOD, nitrogen and phosphorous in a single treatment tank if biofilms are used.

In addition, it was discovered that rather than biofilms that are configured by EPS with high viscosity, which lead to viscosity bulking, and are produced when microbes feel stress in a standard activated sludge process, biofilms that are configured by EPS that is produced when microbes perform nitrate respiration (hereinafter, referred to as “nitrate respiration biofilms”) are suitable as biofilms that allows microbes with different metabolic systems to live in symbiosis efficiently inside a biological treatment tank.

Furthermore, with respect to treatability retention at a dissolved oxygen concentration of less than or equal to 1 mg/L, it was it is difficult to cope with small changes in raw material water conditions and operating conditions, but the present invention was completed by the discovery that as a result of adding a nitrate and an alkali, the continuance of stable operation and treatability retention are even possible in response to large changes in raw material water conditions and operating conditions.

[0013]

That is, the present invention includes the following aspects.

[1] A waste water treatment method comprising the steps of adding a nitrate and an alkali to waste water, and aerating the waste water so that an oxidation-reduction potential inside a biological treatment tank that biologically

treats the waste water is greater than or equal to ± 0 mV, and a dissolved oxygen concentration is less than or equal to 1 mg/L.

[2] The waste water treatment method according to [1], in which a denitrifying bacteria, a nitrogen-fixing bacteria, and a nitrifying bacteria are present in the biological treatment tank.

[3] The waste water treatment method according to [2], in which, nitrogen (N) is recycled inside the biological treatment tank as a result of a denitrifying reaction by the denitrifying bacteria, which degrades BOD in the waste water and creates nitrogen gas (N_2) from nitrite ions (NO_2^-) and nitrate ions (NO_3^-), a nitrogen-fixing reaction by the nitrogen-fixing bacteria, which creates ammonia (NH_3) from the nitrogen gas (N_2), the ammonia becoming ammonium ions (NH_4^+) in a treatment liquid, and a nitrifying reaction by the nitrifying bacteria, which creates nitrite ions (NO_2^-) and nitrate ions (NO_3^-) from the ammonium ions (NH_4^+), being performed concurrently.

[4] A waste water treatment system that treats waste water, in which the system includes a biological treatment tank that biologically treats the waste water, a nitrate addition means that adds a nitrate to the waste water, and an alkali addition means that adds an alkali to the waste water.

[5] The waste water treatment system according to [4], in which a denitrifying bacteria, a nitrogen-fixing bacteria, and a nitrifying bacteria are present in the biological treatment tank.

Advantageous Effects of Invention

[0014]

According to the waste water treatment method and the waste water treatment system of the present invention, it is possible to simultaneously achieve the enhancement of treatment ability, reductions in the power consumption and amount of surplus sludge and suppressions in the bad odor generation and bulking in a case of treating waste water that contains BOD, and the continuance of stable operation and treatability retention are possible.

In addition, according to the waste water treatment method and the waste water treatment system of the present invention, it is possible to perform treatment in a single tank even in a case of treating waste water that contains BOD, and contains either one or both of nitrogen and phosphorous.

In addition, conversion during operation (while retaining treatability) is possible in a case of a facility that is already using the activated sludge process.

Brief Description of Drawing(s)

[0015]

FIG. 1 is a schematic configuration diagram that illustrates an example of a waste water treatment system of the present invention.

FIG. 2 is a chart that illustrates a mechanism with which waste water is biologically treated.

Description of Embodiments

[0016]

Hereinafter, embodiments of the invention will be described with reference to the drawings.

FIG. 1 is a schematic configuration diagram that illustrates an example of a waste water treatment system of the present invention. A waste water treatment system 1 of the example is provided with an adjustment tank 10, a biological treatment tank (hereinafter, also simply referred to as a “treatment tank”) 20, a sedimentation tank 30, a nitrate addition means 41, an alkali addition means 42, a waste water flow channel 51, a transport flow channel 52, a treated water flow channel 53, a surplus sludge flow channel 54, and a returned sludge flow channel 55.

[0017]

The adjustment tank 10 is a tank that adjusts a flow rate and the like of waste water, and is provided with a tank main body 11, which accommodates waste water, and a pump 12, which supplies waste water to the treatment tank 20.

The tank main body 11 is not particularly limited as long as it is capable of accommodating waste water, and for example, a waste water tank or the like can be given as an example thereof.

[0018]

The treatment tank 20 is a tank in which the waste water that is supplied from the adjustment tank 10 is biologically treated, and is provided with a tank main body 21, which accommodates waste water, and an aeration means 22, which aerates the inside of the treatment tank by supplying air.

The aeration means 22 is provided with an air diffusion apparatus 22a, a blower 22b, an air supply pipe 22c, a manometer 22d, and a flow meter 22e. The air diffusion apparatus 22a is disposed in a bottom section of the tank main body 21. The blower 22b supplies air to the air diffusion apparatus 22a. The air

supply pipe 22c connects the air diffusion apparatus 22a and the blower 22b to each other. The manometer 22d and the flow meter 22e are provided between the air diffusion apparatus 22a and the blower 22b.

The tank main body 21 is not particularly limited as long as it is capable of accommodating waste water, and a material that will not be degraded easily by a nitrate or an alkali is preferable.

The aeration means 22 is not particularly limited as long as it is capable of aerating waste water, and for example, it is possible to use a publically-known aeration apparatus.

[0019]

The sedimentation tank 30 is a tank in which solid-liquid separation of treated water, which is obtained by biologically treating waste water in the biological treatment tank 20, and sludge (microbial groups) is performed, and is provided with a tank main body 31, which accommodates treated water and sludge, a scraping device 32, which scrapes separated sludge away, and a pump 33, which returns a portion of the sludge to the biological treatment tank 20.

The structure of the tank main body 31 is not particularly limited.

The scraping device 32 is not particularly limited as long as it is capable of scraping sludge away.

[0020]

The nitrate addition means 41 of this example is a means for adding a nitrate to waste water in the treatment tank 20 either in batches or continuously.

The nitrate addition means 41 is not particularly limited as long as it is capable of adding a nitrate to waste water.

[0021]

The alkali addition means 42 of this example is a means for adding an alkali to waste water in the treatment tank 20 either in batches or continuously.

The alkali addition means 42 is not particularly limited as long as it is capable of adding an alkali to waste water.

[0022]

The waste water flow channel 51 is a flow channel through which waste water is supplied to the treatment tank 20 from the adjustment tank 10.

The transport flow channel 52 is a flow channel through which a mixed liquid of treated water, which is biologically treated in the treatment tank 20, and sludge are transferred to the sedimentation tank 30 from the treatment tank 20.

The treated water flow channel 53 is a flow channel through which treated water, separated in the sedimentation tank 30, is discharged outside the system from the sedimentation tank 30.

The surplus sludge flow channel 54 is a flow channel through which a portion of sludge, separated in the sedimentation tank 30, is discharged outside the system from the sedimentation tank 30 as surplus sludge.

The returned sludge flow channel 55 is a flow channel through which a portion of sludge, separated in the sedimentation tank 30 is returned to the treatment tank 20 from the sedimentation tank 30 as returned sludge.

[0023]

A waste water treatment method that is used in the waste water treatment system 1 illustrated in FIG. 1 includes the following steps (a) to (c).

Step (a): A step of making the flow rate, the concentration, and the like of the waste water uniform in the adjustment tank 10.

Step (b): A step of biologically treating waste water supplied from the adjustment tank 10 in the treatment tank 20.

Step (c): A step of performing solid-liquid separation of a mixed liquid of treated water and sludge into treated water and sludge in the sedimentation tank 30.

[0024]

<Waste Water>

The waste water that is treated in the present invention is not particularly limited as long as it is organic waste water, and industrial wastewater, domestic wastewater, human waste and the like can be given as examples thereof. In addition, in addition to BOD, nitrogen and phosphorous may be contained in the waste water.

[0025]

<Step (a)>

In Step (a), the flow rate, the load components and the load concentration of waste water, and the like are made to be as uniform as possible in the adjustment tank 10.

[0026]

<Step (b)>

In Step (b), a nitrate is added to waste water by the nitrate addition means 41, and an alkali is added by the alkali addition means 42. Furthermore, waste water, to which a nitrate and an alkali have been added, is aerated by the aeration

means 22 so that the oxidation-reduction potential in the treatment tank 20 is greater than or equal to ± 0 mV, and the dissolved oxygen (DO) concentration is less than or equal to 1 mg/L (hereinafter, referred to as “low aeration”). Waste water is biologically treated as a result of the abovementioned process. A mechanism with which waste water is biologically treated will be described with reference to FIG. 2.

Additionally, the oxidation-reduction potential is measured at a liquid temperature of 25°C using an oxidation-reduction potential meter (for example, a “D-13” manufactured by Horiba, Ltd.). The dissolved oxygen concentration is measured at a liquid temperature of 25°C using a dissolved oxygen concentration meter (for example, an “OM-51” manufactured by Horiba, Ltd.).

[0027]

In the present invention, the biological treatment of waste water is achieved by the following four steps. Broadly speaking, the activation of metabolites (the transformation of metabolic pathways in a case of converting from the activated sludge process) includes the three stages of a first stage to a third stage mentioned below. In FIG. 2, an example in which an aerobic treatment, which is the activated sludge process, is provided as a Preliminary Step mentioned below, but the present invention can also be realized in a case in which an aerobic treatment is not included.

First Stage: Activation of the denitrifying reaction (the induction of nitrate respiration from oxygen respiration in a case of converting from the activated sludge process)

Second Stage: Activation of the nitrogen-fixing reaction

Third Stage: Activation of the nitrifying reaction

[0028]

When the denitrifying reaction (denitrification due to nitrate respiration) is activated (when the metabolic pathways transition from oxygen respiration to nitrate respiration in a case of converting from the activated sludge process), the reactions of the First Stage to the Third Stage proceed in a simultaneous parallel manner due to a Fourth Stage mentioned below.

Fourth Stage: Symbiosis of microbes in nitrate respiration biofilm formed during nitrate respiration (symbiosis of organisms)

[0029]

(Preliminary Step)

In the activated sludge process, the majority of the process is in an aerobic atmosphere, and microbes degrade BOD due to oxygen respiration. However, in anaerobic portions, which account for a small part such as inside a floc or the like, BOD is degraded due to sulfur respiration, fermentation, and the like.

(First Stage)

When a nitrate is added to waste water and aeration is performed so that the oxidation-reduction potential inside the treatment tank is greater than or equal to ± 0 mV, and the dissolved oxygen concentration is less than or equal to 1 mg/L, the microbes inside the treatment tank degrade BOD in waste water due to nitrate respiration (activation of the denitrifying reaction in which BOD in waste water is set as an organic carbon source).

In a case of converting from the activated sludge process, when a nitrate is added to waste water and aeration is performed so that the oxidation-reduction potential inside the treatment tank is greater than or equal to ± 0 mV, and the dissolved oxygen concentration is less than or equal to 1 mg/L, nitrate respiration is induced from oxygen respiration. More specifically, nitrate respiration is induced from oxygen respiration in microbes in aerobic portions, which are the vast majority, and nitrate respiration is induced from sulfur respiration and fermentation in microbes in anaerobic portions, which account for a small part.

[0030]

As illustrated in FIG. 2, the microbes (the denitrifying bacteria and the like) that perform nitrate respiration (in which nitrate respiration is induced) create nitrogen gas (N_2) from nitrite ions (NO_2^-) and nitrate ions (NO_3^-) by degrading BOD (the denitrifying reaction).

At this time, alkalis (such as carbonic acid (H_2CO_3), and bicarbonate ions (HCO_3^-)), and a nitrate respiration biofilm, which will be described later, is also created.

Bacteria belonging to the Flavobacteriaceae, the Sphingobacteriaceae, the Rhodocyclaceae, the Flexibacteraceae, the Comamonadaceae and the like are used as the denitrifying bacteria.

Additionally, in addition to degrading BOD, the bacteria mainly create nitrogen gas (N_2) from nitrite ions (NO_2^-).

[0031]

(Second Stage)

The nitrogen gas (N_2) that is created by the denitrifying reaction is transformed into ammonia by microbes (the nitrogen-fixing bacteria and the like)

(activation of the nitrogen-fixing reaction). The ammonia (NH_3) that is created by this reaction is ionized in water and becomes ammonium ions (NH_4^+).

Bacteria belonging to the Rhodocyclaceae, the Rhodobacteriaceae, the Rhodospirillaceae and the like are used as the nitrogen-fixing bacteria.

[0032]

(Third Stage)

When oxygen is dissolved in waste water in the presence of the ammonium ions (NH_4^+) that are created in the Second Stage and the alkali that is created in the First Stage, the ammonium ions (NH_4^+) are oxidized into nitrate ions (NO_3^-) after becoming nitrite ions (NO_2^-) by microbes (nitrifying bacteria such as nitrite bacteria and nitrate bacteria) (the nitrifying reaction).

The nitrifying reaction proceeds as a result of the alkali that is created by the denitrifying reaction of the First Stage, but the nitrifying reaction proceeds efficiently as a result of adding an alkali to waste water in advance with the nitrate in Step (b).

Bacteria belonging to the Nitrospiraceae, the Nitrosomonadaceae and the like are used as the nitrifying bacteria.

[0033]

The nitrite ions (NO_2^-) and the nitrate ions (NO_3^-) that are created by the nitrifying reaction of the Third Stage are used as the nitrate for nitrate respiration of the microbes in the First Stage. In this manner, in the present invention, nitrogen (N) is recycled in the First Stage to the Third Stage as a result of the form thereof being changed from nitrogen gas (N_2) into nitrite ions (NO_2^-) via ammonium ions (NH_4^+), and being further changed into nitrate ions (NO_3^-).

[0034]

(Fourth Stage)

During nitrate respiration, ATP synthesis amounts fall to amounts that are lower than during oxygen respiration. Accordingly, microbes produce EPS in order to capture more nutrients, and a nitrate respiration biofilm of different microbes (a microbial consortium) is formed. As a result of this, the biofilm changes to the following states (α) to (γ).

(α) In stages 1 to 3, Microbes with different metabolisms including denitrifying bacteria, nitrogen-fixing bacteria, nitrifying bacteria and the like, enter a stable symbiotic state (symbiosis of organisms) inside the biofilm.

(β) Nitrogen (N) enters a state in which amounts of nitrogen (N) that are required in the metabolisms of microbes within the system are stably recycled as

a result of the exchange of the nitrogen gas (N_2), the ammonium ions (NH_4^+), the nitrate ions (NO_3^-) and the like that are mutually created inside the biofilm (in-system nitrogen recycling).

(γ) The treatability of waste water rises (a rise in the degradability of substances with low degradability, and the like) as a result of microbial groups that have entered a symbiotic state being able to metabolize substances that it is not possible for a single type of microbes to metabolize.

[0035]

Sodium nitrate, potassium nitrate, magnesium nitrate, calcium nitrate and the like can be given as examples of the nitrate that is added to waste water. These nitrates may be used singly or in a combination of two or more thereof.

In a case of adding a nitrate to waste water inside the treatment tank 20, as illustrated in FIG. 1, a nitrate addition amount is preferably greater than or equal to 0.1 mg $-NO_3-N/L$ with respect to an amount of treated water, and is more preferably greater than or equal to 0.5 mg $-NO_3-N/L$. It is possible to sufficiently induce nitrate respiration in the microbes in the First Stage as long as the nitrate addition amount is greater than or equal to 0.1 $-NO_3-N/L$. In addition, since it leads to an increase in chemical costs if the nitrate addition amount is increased, the nitrate addition amount is preferably less than or equal to 20 mg $-NO_3-N/L$, is more preferably less than or equal to 10 mg $-NO_3-N/L$, and is even more preferably less than or equal to 5 mg $-NO_3-N/L$.

In addition, in a case in which greater than or equal to 0.5 mg $-NO_3-N/L$ of nitrate nitrogen is contained in waste water to be treated, there are cases in which it is even possible to retain stable treatability without adding a nitrate.

[0036]

Sodium bicarbonate, sodium carbonate, carbonic acid, sodium hydroxide and the like can be given as examples of the alkali that is added to waste water. These alkalis may be used singly or in a combination of two or more thereof.

In a case of adding an alkali to waste water inside the treatment tank 20, as illustrated in FIG. 1, an alkali addition amount is preferably greater than or equal to 0.6 mg as $CaCO_3/L$ at M alkalinity with respect to an amount of treated water, and is more preferably greater than or equal to 3 mg as $CaCO_3/L$. The nitrifying reaction in the Third Stage proceeds sufficiently as long as the alkali addition amount is greater than or equal to 0.6 mg as $CaCO_3/L$ at M alkalinity. In addition, since it leads to an increase in chemical costs if the alkali addition

amount is increased, the alkali addition amount is preferably less than or equal to 50 mg as CaCO_3/L at M alkalinity.

In addition, in a case in which an alkali is added to waste water inside the treatment tank 20, as illustrated in FIG. 1, the pH of the waste water inside the treatment tank 20 and the sedimentation tank 30 is preferably adjusted to be from 6.0 to 8.6.

In addition, in a case in which the M alkalinity of raw material water is greater than or equal to 50 mg as CaCO_3/L , there are cases in which it is even possible to retain stable treatability without adding an alkali.

[0037]

The oxidation-reduction potential inside the treatment tank 20 due to low aeration is greater than or equal to ± 0 mV, and the dissolved oxygen concentration is less than or equal to 1 mg/L. As long as the dissolved oxygen concentration inside the treatment tank 20 is less than or equal to 1 mg/L, activity inhibition of the denitrifying bacteria hardly occurs, and it is possible to induce nitrate respiration from oxygen respiration in aerobic microbes.

In addition, in the manner described above, dissolved oxygen in the waste water is required in the nitrifying reaction of the Third Stage, but as long as the oxidation-reduction potential is greater than or equal to ± 0 mV, it doesn't matter if dissolved oxygen is low.

Accordingly, in the biological treatment, aeration is preferably performed so that the oxidation-reduction potential inside the treatment tank 20 is greater than or equal to ± 0 mV and the dissolved oxygen concentration is less than or equal to 0.3 mg/L, and it is more preferable that the oxidation-reduction potential is greater than or equal to ± 0 mV and the dissolved oxygen concentration is less than or equal to 0.1 mg/L. However, in a case of converting from the activated sludge process or the like, the dissolved oxygen concentration in the waste water may be greater than or equal to 1 mg/L at stages in which the activation of metabolites of microbes has not progressed sufficiently.

[0038]

<Step (c)>

In Step (c), solid-liquid separation of waste water that has been biologically treated into sludge (microbes) and a supernatant fluid (treated water) is performed in the sedimentation tank 30.

The supernatant fluid (treated water) that is separated in the sedimentation tank 30 is discharged outside the system via the treated water flow channel 53.

The sludge that is separated in the sedimentation tank 30 is returned to the treatment tank 20 via the returned sludge flow channel 55 as returned sludge. In addition, a portion of the sludge is discharged outside the system via the surplus sludge flow channel 54 as surplus sludge.

[0039]

<Effects>

According to the present invention, since a nitrate and an alkali are added to waste water, and low aeration is performed so that the oxidation-reduction potential inside the treatment tank, which performs biological treatment of the waste water, is greater than or equal to ± 0 mV and the dissolved oxygen concentration is less than or equal to 1 mg/L, microbes perform nitrate respiration, a denitrifying reaction sufficiently proceeds, and a nitrate respiration biofilm is created. Further, since the symbiosis of microbes with different metabolic systems (denitrifying bacteria, nitrogen-fixing bacteria, nitrifying bacteria and the like) is possible as a result of the nitrate respiration biofilm, even if BOD and nitrogen are contained in waste water, it is possible to treat these simultaneously in a single treatment tank.

In addition, as a result of nitrogen being recycled in the system, it is even possible to perform stable BOD treatment with a nitrate addition of approximately from 0.1 to 20 mg $-\text{NO}_3\text{-N/L}$ in a case in which nitrogen is not contained in the waste water.

In addition, as a result of phosphate-accumulating bacteria also living in symbiosis in the biofilm, it is also possible to simultaneously perform treatment of phosphorous. Additionally, the adsorption and coagulation of the biofilm substrate is highly efficient, and therefore, it is possible to efficiently treat waste water.

Accordingly, if the present invention is used, it is possible to reduce the number of treatment tanks in comparison with biological nitrogen treatment and phosphorous treatment methods of the related art (nitrification-denitrification processes, anaerobic-aerobic processes (AO processes), anaerobic-anoxic-oxic processes (A2O processes), anaerobic-nitrification and endogenous denitrification processes (AOAO processes), and the like).

[0040]

In addition, if the present invention is used, since the biofilm has a cushioning role with respect to the microbes, the microbes are resistant to sudden load fluctuations. In addition, since the biofilm also has a protective role from

biological inhibitors and toxins, resistance with respect to biological inhibitors, toxins and the like is also raised. In addition, the degradation of organic matter with low degradability, which is difficult to treat, is also promoted in the activated sludge process by the symbiosis of microbes. Therefore, since high load treatment are possible in comparison with processes of the related art (the activated sludge process), it is possible to reduce installation area. Furthermore, as organisms, resistance in harsh conditions is enhanced, and since it is also possible to suppress bulking, operational management is easy.

[0041]

In addition, if the present invention is used, since it is suitable as long as low aeration is performed so that the dissolved oxygen concentration inside the treatment tank is less than or equal to 1 mg/L, it is possible to reduce power consumption.

[0042]

In addition, if the present invention is used, since the metabolism of microbes is changed from oxygen respiration to nitrate respiration, ATP synthesis amounts are reduced in cases in which the same amount of BOD is degraded, and therefore, it is also possible to reduce the amount of surplus sludge that is generated.

[0043]

In addition, if the present invention is used, since sulfur respiration and fermentation are suppressed in the microbes, the generation of organic acids, alcohols, hydrogen sulfide and the like is suppressed, and therefore, it is possible to reduce the generation of bad odors. In addition, by suppressing hydrogen sulfide, it is also possible to suppress corrosion and deterioration of concrete water tanks, water channels, steel canned products and the like.

[0044]

In addition, if the present invention is used, as a result of adding a nitrate and an alkali to waste water, the continuance of stable operation and treatability retention are even possible in response to large changes in raw material water conditions and operating conditions.

[0045]

In addition, if the present invention is used, as a result of the nitrate respiration biofilm capturing insoluble fine suspended matter, the transparency of treated water is improved, and treated water quality is also improved (the suspended solid concentration (SS concentration) of treated water is reduced).

[0046]

In the abovementioned manner, in the present invention, nitrogen (N) is recycled in the First Stage to the Third Stage as a result of the form thereof being changed from nitrogen gas (N_2) into nitrate ions (NO_3^-) and the like via ammonium ions (NH_4^+). In addition, the alkali that is necessary in the nitrifying reaction of the Third Stage is created by the denitrifying reaction of the First Stage. Accordingly, it is suitable as long as the addition of a nitrate and an alkali to the waste water in Step (b) is at least performed during the initiation of operation of the waste water treatment system. That is, it is suitable as long as a nitrate and an alkali are added from outside the system to at least the waste water that is initially biologically treated. In subsequent biological treatments, since the nitrate ions (NO_3^-) that are created from the First Stage to the Third Stage, nitrogen gas (N_2) in aeration air and the alkali that is created in the First Stage are present in the system, there are cases in which it is possible for the reactions of the First Stage to the Third Stage to proceed in simultaneous parallel manner as a result of the Fourth Stage even when a nitrate and an alkali are not added to the waste water from outside the system.

However, in a case in which the nitrate concentration or the alkali concentration in the system decreases, a nitrate or an alkali may be newly added to the waste water.

[0047]

<Other Embodiments>

The waste water treatment method of the present invention is not limited to the abovementioned method. In the abovementioned method, as illustrated in FIG. 1, the nitrate and the alkali are only added to the waste water inside the treatment tank 20, but the nitrate and the alkali may be added at any point prior to the treatment tank 20 (in the treatment tank 20 or upstream thereof). In other words, the nitrate may be added from the nitrate addition means 41, and the alkali added from the alkali addition means 42 to the waste water in the adjustment tank 10 only. In addition, the nitrate may be added from the nitrate addition means 41, and the alkali added from the alkali addition means 42 to the waste water in both the adjustment tank 10 and the treatment tank 20. Furthermore, the nitrate may be added from the nitrate addition means 41 to the waste water in the adjustment tank 10, and the alkali may be added from the alkali addition means 42 to the waste water in the treatment tank 20, and vice-versa.

In addition, the nitrate may be added from the nitrate addition means 41, and the alkali added from the alkali addition means 42 to the waste water at any point further upstream of the adjustment tank 10 (points upstream of the adjustment tank 10, and therefore, waste water of one, multiple, or all streams in a case in which multiple streams of waste water flow into the adjustment tank 10). [0048]

In addition, in the abovementioned method, the flow rate of the waste water, the concentration of the waste water, and the like is made to be uniform in the adjustment tank 10 as Step (a), but there are cases in which Step (a) need not be performed.

In addition, there are cases in which another step such as a step of removing large and small solid content or the like (a screen, a solids removal device (coagulation-sedimentation, pressure floatation or the like), a sedimentation tank or the like) is provided before Step (a), or between Step (a) and Step (b).

In addition, in the abovementioned method, solid-liquid separation of a mixed liquid of treated water and sludge into treated water and sludge is performed in the sedimentation tank 30 as Step (c), but the sedimentation tank 30 may be replaced with an apparatus that is provided with a separation function of sludge and treated water such as a membrane separation apparatus. Additionally, in a case in which a membrane separation apparatus is installed in the treatment tank 20, the transport flow channel 52 and the returned sludge flow channel 55 are not necessary, and the treated water flow channel 53 and the surplus sludge flow channel 54 have a shape that leads out from the treatment tank 20.

Furthermore, in the abovementioned method, the waste water is biologically treated in a single treatment tank 20, but a plurality of treatment tanks 20 may be used. In the abovementioned manner, if the present invention is used, it is possible to treat waste water in a single treatment tank even in a case of treating waste water that contains BOD, nitrogen and phosphorous, but multiple treatment tanks 20 may also be used. [0049]

In addition, with the exception of trickling filter processes, the present invention can be applied to biofilm treatment processes (immersion filter bed processes, fluidized bed processes, carrier-added activated sludge processes, rotating disk processes, rocking bed processes and the like).

In a case in which the present invention is applied to a biofilm treatment process, it is sufficient as long as the nitrate and the alkali are added to the waste water before the biofilm treatment tank (in the biofilm treatment tank or upstream thereof), and low aeration (to an oxidation-reduction potential of greater than or equal to ± 0 mV and a dissolved oxygen concentration of less than or equal to 1 mg/L) of the biofilm treatment tank is performed.

Additionally, the material and shape of a filter media that is used in a biofilm treatment process is not limited.

[0050]

In addition, the present invention can be applied to a dispersed bacteria treatment process.

A dispersed bacteria treatment process is a treatment process in which BOD in waste water is oxidatively degraded, and transformed into non-coagulable bacteria by non-coagulable bacteria (dispersed bacteria) in the effective absence of protozoans and metazoans.

(1) The addition of a dispersed bacteria preparation, (2) the non-addition of protozoans and metazoans (not performing activated sludge return or the like), (3) setting so that it is not possible for protozoans and metazoans to proliferate during detention periods of a treatment tank, (4) the insertion or installation of a filter media (an immobilized filter, a fluid carrier, a rocking fiber filter or the like) that can maintain or fix dispersed bacteria, and (5) a combination of (1) to (4) above are methods in which protozoans and metazoans are set to be effectively absent, and non-coagulable bacteria are prioritized.

In a case of adopting the present invention in a dispersed bacteria treatment process, it is sufficient as long as the nitrate and the alkali are added to the waste water before a dispersed bacteria treatment tank (in the dispersed bacteria treatment tank or upstream thereof), and low aeration (to an oxidation-reduction potential of greater than or equal to ± 0 mV and a dissolved oxygen concentration of less than or equal to 1 mg/L) of the dispersed bacteria treatment tank is performed.

Additionally, the material and shape of the filter media that is inserted in (4) above is not limited.

[0051]

In addition, the present invention can be applied to a substitute treatment of an anaerobic treatment process.

In a case in which the present invention is applied to a substitute treatment of an anaerobic treatment process, it is sufficient as long as the nitrate and the alkali are added to the waste water before an anaerobic treatment tank (in the anaerobic treatment tank or upstream thereof), an aeration apparatus is attached to the anaerobic treatment tank, and low aeration (to an oxidation-reduction potential of greater than or equal to ± 0 mV and a dissolved oxygen concentration of less than or equal to 1 mg/L) of the anaerobic treatment tank is performed. In a case in which there is a preliminary oxidation treatment tank in the first part of the anaerobic treatment tank, it is sufficient as long as the nitrate and the alkali are added to the waste water before the preliminary oxidation treatment tank (in the preliminary oxidation treatment tank or upstream thereof), and low aeration of the preliminary oxidation treatment tank and the anaerobic treatment tank is performed.

Additionally, in a case in which a filter media is inserted into the anaerobic treatment tank, the material and shape of the filter media that is inserted is not limited.

[0052]

In addition, the present invention can be applied to a substitute treatment of a latter part in a case in which a high load treatment apparatus (an anaerobic treatment process, a biofilm treatment process, a dispersed bacteria treatment process or the like) is placed in a first part, and an activated sludge treatment apparatus or a biofilm treatment apparatus is used as a finishing treatment in a latter part.

In a case in which the present invention is adopted in a substitute treatment of a latter part biological treatment apparatus in which a high load treatment apparatus is placed in a first part, it is sufficient as long as the nitrate and the alkali are added to the waste water before a latter part biological treatment tank (an activated sludge treatment tank or a biofilm treatment tank) (in the latter part biological treatment tank or upstream thereof), and low aeration (to an oxidation-reduction potential of greater than or equal to ± 0 mV and a dissolved oxygen concentration of less than or equal to 1 mg/L) of the latter part biological treatment tank is performed.

Additionally, in a case in which the latter part biological treatment tank is a biofilm treatment tank, the material and shape of the filter media that is inserted is not limited.

Examples

[0053]

Hereinafter, the present invention will be specifically described using working examples. However, the present invention is not limited to these examples.

[0054]

Working Example 1

The waste water treatment system 1 illustrated in FIG. 1 was used, the waste water was set to be population sewage water, and a sludge for acclimatization used returned sludge from a sewage water treatment plant. A 60 L waste water tank was used as the tank main body 11 of the adjustment tank 10. In addition, the volume of the tank main body 21 of the treatment tank 20 was 10 L, and the volume of the tank main body 31 of the sedimentation tank 30 was 10 L.

Waste water was supplied from the waste water tank to the treatment tank 20 with a condition of a treated water amount of 3.5 L/day, and with respect to the treated water amount, 2 mg $\text{-NO}_3\text{-N/L}$ of calcium nitrate and 8 mg as $\text{CaCO}_3\text{/L}$ of an aqueous solution of sodium bicarbonate with a concentration of 5% by mass were added to the waste water in the treatment tank 20. Furthermore, the waste water was biologically treated by aerating the treatment tank 20 using the aeration means 22 so that the oxidation-reduction potential inside the treatment tank 20 was greater than or equal to ± 0 mV and the dissolved oxygen concentration was less than or equal to 1 mg/L. At this time, the temperature inside the treatment tank 20 was 25°C, and the aeration air flow was adjusted while checking the dissolved oxygen concentration. Subsequently, solid-liquid separation of a mixed liquid of treated water and sludge into treated water and sludge was performed in the sedimentation tank 30, the treated water was discharged outside the system, and a portion of the sludge was returned to the treatment tank 20 as returned sludge. The returned sludge rate was set to 100% of the treated water amount. The surplus sludge was discharged outside the system in batches while checking a sludge interface of the sedimentation tank.

Additionally, the addition method of the calcium nitrate and the sodium bicarbonate aqueous solution was a batch method, and there were periods during the test period in which the two substances were not added. In addition, the oxidation-reduction potential inside the treatment tank during the treatment period was from 40 to 250 mV, the dissolved oxygen concentration was less than

or equal to 0.36 mg/L, and an average aeration air flow was 270 NmL/min. The oxidation-reduction potential was measured using an oxidation-reduction potential meter (a “D-13” manufactured by Horiba, Ltd.), and the dissolved oxygen concentration was measured using a dissolved oxygen concentration meter (an “OM-51” manufactured by Horiba, Ltd.).

The chemical amounts and characteristics (the results of water quality analysis) of the population sewage water that was used as the waste water are illustrated in Table 1, and the treatment conditions (the operating conditions) of the waste water are illustrated in Table 2.

[0055]

Treated water that was treated with the abovementioned test conditions was collected, and the characteristics thereof were analyzed. In addition, removal rates of BOD and total nitrogen (T-N), a BOD sludge conversion rate, and an estimated sludge loss rate were determined using the following methods. The results are illustrated in Table 3.

[0056]

BOD Removal Rate (%) = ((BOD Amount in Waste Water Before Treatment - BOD amount in Treated Water) / BOD Amount in Waste Water Before Treatment) × 100

Total Nitrogen (T-N) Removal Rate (%) = ((Total Nitrogen Amount in Waste Water Before Treatment - Total Nitrogen amount in treated water) / Total Nitrogen Amount in Waste Water Before Treatment) × 100

BOD Sludge Conversion Rate (%) = ((Sludge Increase in Treatment Tank and Sedimentation Tank in Specific Period + Surplus Sludge Draw-Out Amount in Specific Period) / Treated BOD Amount in Specific Period) × 100

Estimated Sludge Loss Rate (%) = (Average BOD Sludge Conversion Rate in Current Test / BOD Sludge Conversion Rate (from 40 to 50%) in Activated Sludge) × 100

[0057]

[Table 1]

		Concentration
Chemical Addition Amounts	Peptone	1063 mg/L
	Glucose	500 mg/L
	Fish Meat Extract	300 mg/L
	Sodium Chloride	670 mg/L
	Phosphoric Acid - Potassium	88 mg/L
	Ammonium Chloride	380 mg/L
	Magnesium Sulfate	0.1 mg/L

	Calcium Chloride	0.1 mg/L
Water Quality Analysis Results	BOD	1700 mg/L
	T-N	290 mg/L
	Org-N	110 mg/L
	NH ₄ -N	180 mg/L
	NO ₂ -N	< 0.1 mg/L
	NO ₃ -N	< 0.1 mg/L

[0058]

[Table 2]

Operating Conditions	Treated Water Amount	3.5 L/Day
	Treatment Tank Volume	10 L
	Treatment Tank Oxidation-Reduction Potential	from 40 to 250 mV
	Treatment Tank Dissolved Oxygen Concentration	Less than or equal to 0.36 mg/L
	Calcium Nitrate Addition Amount	from 0 to 2 mg-NO ₃ -N/L
	Sodium Bicarbonate Addition Amount	from 0 to 8 mg as CaCO ₃ /L
	Returned Sludge Rate (Treated Water Ratio)	100%
	Average Aeration Air Flow	270 NmL/min
	Treatment Tank Water Temperature	25°C
	Number of Test Days	47 days

[0059]

[Table 3]

		First Embodiment
Treated Water Analysis Results	BOD	4.9 mg/L
	SS	9.2 mg/L
	T-N	129.5 mg/L
	Org-N	2 mg/L
	NH ₄ -N	81 mg/L
	NO ₂ -N	0.5 mg/L
	NO ₃ -N	46 mg/L
Removal Rate	BOD	99.7%
	T-N	55.3%
BOD Sludge Conversion Rate		20.2%
Estimated Sludge Loss Rate		from 50 to 60%

[0060]

In Tables 1 and 3, “BOD” is a biochemical oxygen demand, “T-N” is total nitrogen, “Org-N” is organic nitrogen, “NH₄-N” is ammonia nitrogen, “NO₂-N” is nitrite nitrogen, “NO₃-N” is nitrate nitrogen, and “SS” is suspended solids.
[0061]

As is evident from Table 3, in Working Example 1 it was possible to treat substantially 100% of BOD, and approximately 55% of nitrogen in a single treatment tank.

In addition, it was possible to reduce surplus sludge by from 50 to 60%.
[0062]

Working Example 2

The waste water treatment system 1 illustrated in FIG. 1 was used, the waste water was set to be seasoning factory waste water, and a sludge for acclimatization used returned sludge from a sewage water treatment plant. A 60 L waste water tank was used as the tank main body 11 of the adjustment tank 10. In addition, the volume of the tank main body 21 of the treatment tank 20 was 10 L, and the volume of the tank main body 31 of the sedimentation tank 30 was 10 L.

Waste water was supplied from the waste water tank to the treatment tank 20 with a condition of a treated water amount of 10 L/day, and with respect to the treated water amount, 10 mg -NO₃-N/L of calcium nitrate and an aqueous solution of a sodium hydroxide having a concentration of 5% by mass were added to the waste water in the treatment tank 20 so that the pH in the treatment tank 20 was greater than or equal to 7. Furthermore, the waste water was biologically treated by aerating the treatment tank 20 using the aeration means 22 so that the oxidation-reduction potential inside the treatment tank 20 was greater than or equal to ± 0 mV and the dissolved oxygen concentration was less than or equal to 1 mg/L. At this time, the temperature inside the treatment tank 20 was 25°C, and the aeration air flow was adjusted while checking the dissolved oxygen concentration. Subsequently, solid-liquid separation of a mixed liquid of treated water and sludge into treated water and sludge was performed in the sedimentation tank 30, the treated water was discharged outside the system, and a portion of the sludge was returned to the treatment tank 20 as returned sludge. The returned sludge rate was set to 100% of the treated water amount. The surplus sludge was discharged outside the system in batches while checking a sludge interface of the sedimentation tank 30.

Additionally, the addition method of the calcium nitrate was a batch method, the addition method of the sodium hydroxide was an automatic addition method depending on pH control, and there were periods during the test period in which the two substances were not added. In addition, the oxidation-reduction potential inside the treatment tank during the treatment period was from 55 to 261 mV, the dissolved oxygen concentration was less than or equal to 0.23 mg/L, and the aeration air flow was from 100 to 500 NmL/min. The oxidation-reduction potential was measured using an oxidation-reduction potential meter (a “D-13” manufactured by Horiba, Ltd.), the dissolved oxygen concentration was measured using a dissolved oxygen concentration meter (an “OM-51” manufactured by Horiba, Ltd.), and the pH was measured using a pH meter (a “D-24” manufactured by Horiba, Ltd.).

The characteristics (the results of water quality analysis) of the seasoning factory waste water that was used as the waste water are illustrated in Table 4, and the treatment conditions (the operating conditions) of the waste water are illustrated in Table 5.

[0063]

Treated water that was treated with the abovementioned test conditions was collected, and the characteristics thereof were analyzed. In addition, a removal rate of COD (Chemical Oxygen Demand) was determined using the following method. The results are illustrated in Table 6.

[0064]

COD Removal Rate (%) = ((COD Amount in Waste Water Before Treatment - COD amount in Treated Water) / COD Amount in Waste Water Before Treatment) × 100

[0065]

[Table 4]

		Concentration
Water Quality Analysis Results	COD _{Cr}	680 mg/L
	COD _{Mn}	400 mg/L
	BOD	440 mg/L
	Org-N	9.8 mg/L
	NH ₄ -N	1.7 mg/L
	NO ₂ -N	< 0.1 mg/L
	NO ₃ -N	0.2 mg/L
	T-N	11.6 mg/L
	PO ₄ -P	2.6 mg/L

	T-P	11.7 mg/L
	SS	15.2 mg/L

[0066]

[Table 5]

Operating Conditions	Treated Water Amount	10 L/Day
	Treatment Tank Volume	10 L
	Treatment Tank Oxidation-Reduction Potential	from 55 to 261 mV
	Treatment Tank Dissolved Oxygen Concentration	Less than or equal to 0.23 mg/L
	Calcium Nitrate Addition Amount	from 2 to 10 mg-NO ₃ -N/L
	pH Adjustment Range (5% Sodium Hydroxide Solution Used)	Greater than or equal to pH 7
	Returned Sludge Rate (Treated Water Ratio)	100%
	Aeration Air Flow	from 100 to 500 NmL/min
	Treatment Tank Water Temperature	25°C
	Number of Test Days	35 days

[0067]

[Table 6]

		Embodiment 2
Treated Water Analysis Results	COD _{Mn}	from 10 to 15 mg/L
	SS	from 4 to 10 mg/L
	NO ₂ -N	< 0.1 mg/L
	NO ₃ -N	< 0.1 mg/L
Removal Rate	COD _{Mn}	from 96.3 to 97.5%

[0068]

In Tables 4 and 6, “COD_{Cr}” is an oxygen demand due to potassium dichromate, “COD_{Mn}” is an oxygen demand due to potassium permanganate at 100°C, “BOD” is a biochemical oxygen demand, “Org-N” is organic nitrogen, “NH₄-N” is ammonia nitrogen, “NO₂-N” is nitrite nitrogen, “NO₃-N” is nitrate nitrogen, “SS” is suspended solids, “T-N” is total nitrogen, “PO₄-P” is phosphate phosphorus, and “T-P” is total phosphorous.

[0069]

As is evident from Table 6, in Working Example 2 it was possible to treat greater than or equal to 96% of COD_{Mn} in a single treatment tank.

Industrial Applicability

[0070]

The waste water treatment method of the present invention is effective as a treatment method of waste water that contains BOD. In addition, the waste water treatment method is also effective as a treatment method of waste water that contains BOD and contains either one or both of nitrogen and phosphorous.

Reference Signs List

[0071]

- 1 Waste water treatment system
- 10 Adjustment tank
- 11 Tank main body
- 12 Pump
- 20 Biological treatment tank (treatment tank)
- 21 Tank main body
- 22 Aeration means
- 22a Air diffusion apparatus
- 22b Blower
- 22c Air supply pipe
- 22d Manometer
- 22e Flow meter
- 30 Sedimentation tank
- 31 Tank main body
- 32 Scraping device
- 33 Pump
- 41 Nitrate addition means
- 42 Alkali addition means
- 51 Waste water flow channel
- 52 Transport flow channel
- 53 Treated water flow channel
- 54 Surplus sludge flow channel
- 55 Returned sludge flow channel

CLAIMS

[Claim 1]

A waste water treatment method comprising the steps of:
adding a nitrate and an alkali to waste water; and
aerating the waste water so that an oxidation-reduction potential inside a biological treatment tank that biologically treats the waste water is greater than or equal to ± 0 mV, and a dissolved oxygen concentration is less than or equal to 1 mg/L.

[Claim 2]

The waste water treatment method according to claim 1, wherein a denitrifying bacteria, a nitrogen-fixing bacteria, and a nitrifying bacteria are present in the biological treatment tank.

[Claim 3]

The waste water treatment method according to claim 2, wherein nitrogen (N) is recycled inside the biological treatment tank as a result of a denitrifying reaction by the denitrifying bacteria, which degrades BOD in the waste water and creates nitrogen gas (N_2) from nitrite ions (NO_2^-) and nitrate ions (NO_3^-), a nitrogen-fixing reaction by the nitrogen-fixing bacteria, which creates ammonia (NH_3) from the nitrogen gas (N_2), the ammonia becoming ammonium ions (NH_4^+) in a treatment liquid, and a nitrifying reaction by the nitrifying bacteria, which creates nitrite ions (NO_2^-) and nitrate ions (NO_3^-) from the ammonium ions (NH_4^+), being performed concurrently.

[Claim 4]

A waste water treatment system that treats waste water, the system comprising:
a biological treatment tank that biologically treats the waste water;
a nitrate addition means that adds a nitrate to the waste water; and
an alkali addition means that adds an alkali to the waste water.

[Claim 5]

The waste water treatment system according to claim 4, wherein a denitrifying bacteria, a nitrogen-fixing bacteria, and a nitrifying bacteria are present in the biological treatment tank.