WASTEWATER TREATMENT APPARATUS AND WASTEWATER TREATMENT METHOD

Technical Field

[0001]

The present invention relates to a wastewater treatment apparatus and a wastewater treatment method, more particularly, to a wastewater treatment apparatus in which, after water to be treated is biologically treated, when flocculation treatment is performed by adding a flocculant for removing a dissolved material or a suspended material such as a fungus body or a biological metabolite in the thus-biologically treated water, the treated water having a good quality is obtained with a reduced amount of the flocculant being used and a wastewater treatment method.

In this specification, the term of flocculation is not distincted from the term of coagulation and flocculation is used in the meanings of either flocculation or coagulation.

Background Art

[0002]

A biological treatment method is widely used as a method for treating organic wastewater. In order to remove a pollutant such as a suspended material or a dissolved material in biologically treated water, or in order to recover water when an amount of discharged water is large, a flocculation treatment is performed on the biologically treated water and,

further, a membrane treatment is performed after the flocculation treatment.

[0003]

For example, in JP-A-2005-238152, described is a method in which organic material-containing water is biologically treated and, then, a flocculation treatment is performed on the thus-biologically treated water by adding a flocculant thereto and, thereafter, solid-liquid separation is performed on the resultant water subjected to the flocculation treatment and, subsequently, the water subject to the separation is filtered by using a filtration apparatus and, then, a membrane treatment is performed on the thus-filtered water by using a reverse osmosis membrane separator. Further, in this method, a dissolved air flotation separator is described as a solid-liquid separation unit. The dissolved air flotation separator as the solid-liquid separation unit has an advantage such that a space needed for installing it is smaller than that for a sedimentation tank.

[0004]

Since the flocculant (inorganic flocculant) which is added for facilitating the flocculation action at the time of performing the flocculation treatment on the biologically treated water is a factor directly connected with a running cost, a reduction of the amount thereof to be added is required; however, in the flocculation treatment of the biologically

treated water, it is difficult to perform the flocculation treatment on the dissolved organic matter (S-TOC), particularly, biological metabolite and, ordinarily, a large amount of flocculant is required.

[0005]

Particularly, in recent years, an emphasis is put on recycle of water resource and, then, recovery of wastewater is performed; however, in order to highly purify the water discharged as wastewater up to a level at which the water can be used again after being subjected to the biological treatment, a large amount of flocculant is needed. For this account, it becomes a large problem to reduce an amount of the flocculant to be added.

[0006]

As for the method for reducing the amount of the flocculant to be added, a method for simultaneously using a high-molecular flocculant or the like is proposed; however, this method is expensive because of increase of addition of the high-molecular flocculant. Therefore, it is a present situation in which an easy low-cost method is required.

[Patent Reference 1] JP-A-2005-238152

Disclosure of the Invention

Problems the Invention is to solve

[0007]

The present invention has an object to provide a

wastewater treatment apparatus in which these conventional problems can be solved and, after water to be treated is biologically treated, when flocculation treatment is performed by adding a flocculant for removing a dissolved material or a suspended material such as a fungus body or a biological metabolite in the thus-biologically treated water, the treated water having a good quality can be obtained with a reduced amount of the flocculant being used and a wastewater treatment method.

Means for solving the Problems

[0008]

In order to solve these problems, the present inventors have exerted intensive studies and, as a result, have found that, when a flocculation treatment is performed on a fungus body, biological metabolite and the like after being subjected to a biological treatment, an amount of the flocculant to be added can be reduced by performing aeration at the time of performing stirring in a flocculation reaction tank and then, performing dissolved air flotation separation on the water subjected to the flocculation treatment and, further, found that a quality of the treated water can be enhanced by adjusting the water in a flocculation reaction system to be in an optimal pH region and simultaneously using an oxidant.

[0009]

The present invention has been achieved based on these

findings and has following aspects:

(1) a wastewater treatment apparatus, comprising:

a biological reaction tank for biologically treating water to be treated;

a flocculation reaction tank for conducting a flocculation reaction by adding a flocculant to the thus-biologically treated water flowing from the biological reaction tank; and

a dissolved air flotation separator for performing solid-liquid separation on the water subjected to a flocculation treatment flowing from the flocculation reaction tank,

wherein an aeration unit is provided in the flocculation reaction tank;

(2) the wastewater treatment apparatus according to (1) above, further comprising a pH control agent addition unit for adding a pH control agent for adjusting pH of water in the flocculation reaction tank to be in the range of from 3 to 6;

(3) the wastewater treatment apparatus according to (1) or (2) above, further comprising an oxidant addition unit for adding an oxidant into the flocculation reaction tank;

(4) the wastewater treatment apparatus according to any one of (1) to (3) above, further comprising a filtration apparatus which performs the solid-liquid separation on the water subjected to the dissolved air flotation separation

flowing from the dissolved air flotation separator;

(5) a wastewater treatment method, comprising:

a biological reaction step for biologically treating water to be treated;

a flocculation reaction step for conducting a flocculation reaction by adding a flocculant to biologically treated water flowing from the biological reaction step; and

a dissolved air flotation separation step for performing solid-liquid separation on the water subjected to a flocculation treatment flowing from the flocculation reaction step, wherein a flocculation reaction in the flocculation reaction step is conducted under aeration;

(6) the wastewater treatment method according to (5) above, wherein a pH control agent is added to water in the flocculation reaction step for adjusting a pH value of the water to be in the range of from 3 to 6;

(7) the wastewater treatment method according to (5) or (6), wherein an oxidant is added to water in the flocculation reaction step; and

(8) the wastewater treatment method according to any one of (5) to (7), further comprising a filtration step for performing the solid-liquid separation on the water subjected to the dissolved air flotation separation flowing from the dissolved air flotation separation step.

Advantage of the Invention

[0010]

It is difficult to perform the flocculation treatment on dissolved materials or suspended materials including a fungus body or a biological metabolite in the biologically treated water, particularly, the biological metabolite. Ordinarily, a large amount of flocculant is needed. According to the present invention, when the flocculation treatment is performed on the biologically treated water, by performing the treatment by a combination of stirring at the time of performing the flocculation treatment by aeration (ordinarily, with air) and separating flocculation flocs by dissolved air flotation separation, a flocculation ability and a solid-liquid separation ability can be improved and, by such improvement, reduction of the amount of the flocculant to be added can be realized and the treated water having a good quality can be obtained.

[0011]

Although a detail of an action mechanism of such effect as described above according to the invention is not cleared, the mechanism is considered to be those as described below.

[0012]

Namely, although a fungus body in a suspended form in water or a high-molecular organic substance (for example, protein) in a dissolved form in water is present in the biologically treated water, particularly in an apparatus

having a combination of flocculation treatment and filtration, a protein is considered to give a large influence to a quality of filtered water. As can be seen from foams generated in a biologically treating tank, there exist some portions of proteins which have affinity with air. According to the invention, when charges of proteins are neutralized with an inorganic flocculant and the proteins are macroaggregated with one another and, then, exposed to air, it is considered that the thus-macroaggregated proteins come to be in a state in which they are entangled with air bubbles. As a result, when the solid-liquid separation is performed in the latter step of the flocculation reaction tank by means of the dissolved air flotation separation method, they are further entangled with fine bubbles and, then, separation abilities thereof are considered to be enhanced.

[0013]

Particularly in an iron compound type flocculant, when a pH value thereof is in a weakly acidic to a weakly alkaline region, a ferric iron is effective in flocculation. However, for example, even when a ferric chloride (trivalent iron) type flocculant is used, a ferrous iron is slightly present in the flocculant. Then, when aeration is performed in the flocculation reaction tank, the ferrous ion is oxidized to be a ferric ion which is effective in flocculation. Further, when an oxidant such as hypochlorous acid is added to the

flocculation reaction tank, an oxidation effect is further enhanced (Claims 3 and 7). Still further, it is considered that, since many of proteins each have an isoelectric point in the weakly acidic region, as pH moves more to an acidic region (for example, to a pH value of 3 to 6), dissociation to water becomes less and, then, the flocculation effect can be enhanced (Claims 2 and 6).

[0014]

By such action mechanism as described above, according to the invention, the treated water having a high water quality can be obtained with a small amount of the flocculant being added and, further, under following advantages, effective water recovery and recycle can be performed:

(1) reduction of cost of a flocculant caused by reduction of an amount of the flocculant to be added and, further, reduction of cost of a neutralizing agent and reduction of treatment cost of a sludge can be realized;

(2) improvement of dissolved air flotation separation ability of flocculation flocs and reduction of a space required for installing a dissolved air flotation separator to be brought about by the accompanying improvement of water feed rate in the dissolved air flotation separator can be realized; and

(3) an improvement of efficiency in the treatment in the latter step brought about by reduction of the amount of the

flocculant to be added and enhancement of the water quality of separation water generated by the dissolved air flotation separation, namely, reduction of frequency of cleaning of a filtration apparatus when the filtration apparatus is provided in the latter step, and, further, prevention of fouling of an RO membrane of a reverse osmosis (RO) membrane separator when the reverse osmosis (RO) membrane separator is provided in the latter step can be realized.

Best Mode for Carrying Out the Invention

[0015]

Hereinafter, embodiments of wastewater treatment apparatuses and wastewater treatment methods according to the present invention are described in detail.

[0016]

Wastewater

According to the invention, wastewater which is an object to be treated is not particularly limited so long as it is an organic material-containing wastewater which is ordinarily biologically treated and, for example, wastewater from an electronic industry, wastewater from a chemical plant, and wastewater from a food processing plant can be mentioned. For example, in a production process of an electronic part, a large amount of various types of organic wastewater is generated from a developing step, a peeling step, an etching step, a rinsing step and the like and, since it is desired to recover the

wastewater, purify it up to a level of pure water and, then, recycle it, these types of wastewater correspond to wastewater which is an object to be treated according to the invention.

[0017]

Examples of these types of organic wastewater include organic wastewater containing isopropyl alcohol, ethyl alcohol and the like, organic wastewater containing ammonia-state nitrogen and organic-state nitrogen such as monoethanol amine (MEA), and tetramethyl ammonium hydroxide (TMAH) and organic wastewater containing organic sulfur compounds such as dimethyl sulfoxide (DMSO).

[0018]

Biologic treatment

A biological reaction tank for biologically treating wastewater is not particularly limited so long as it is excellent in decomposition efficiency of an organic material and a known aerobic or anaerobic biological reaction tank can be used. For example, a suspension type tank in which activated sludge is held in a suspended state in a tank, and a biological membrane type tank in which activated sludge is attached to a carrier and, then, held can be adopted. Further, in the biological menbrane type tank, any microbial menbrane type tank such as a fixed bed type, a fluid bed type or an expanded bed type is permissible. As for such carriers, any one of activated carbon, various types of plastic carriers, a sponge carrier

and the like can be used.

[0019]

In the suspension type tank, it is needed to provide a solid-liquid separation unit for separating the activated sludge from the treated water. The solid-liquid separation unit such as a sedimentation tank or a membrane separator is provided in the latter step of the biological treatment reaction tank. In other methods, since the activated sludge is held in the biological treatment reaction tank, such solid-liquid separating unit can be omitted.

[0020]

As for such carriers, a sponge carrier is preferred. The sponge carrier can hold microorganisms in a high concentration. A raw material for the sponge carrier is not particularly limited and ester-type polyurethane is favorable. An amount of the carrier to be loaded is not particularly limited and, ordinarily, an apparent volume of the carrier against tank capacity of the biological reaction tank is preferably from about 10 to about 15%.

[0021]

As for the aerobic biological reaction tank which microbially decomposes an organic material in an aerobic state, an aeration tank provided with an oxygen gas supply unit such as an air diffusing pipe or a aeration machine for supplying oxygen (air) into the tank can be used.

[0022]

On the other hand, as for the anaerobic biological reaction tank for microbially decomposing the organic material in an anaerobic state, an anaerobic tank holding the carrier or granular sludge can be used.

[0023]

The biological reaction tank may be either a one-tank type of aerobic biological reaction tank or anaerobic biological reaction tank or a multi-tank type of aerobic biological reaction tank and/or anaerobic biological reaction tank, and the one-tank type may be provided with a partition wall in the tank.

[0024]

Flocculation treatment

According to the invention, when the biologically treated water to be obtained by biologically treating wastewater in the biological reaction tank is subjected to flocculation treatment, the biologically treated water is not only added with a flocculant but also stirred by aeration.

[0025]

<Flocculation tank>

A flocculation reaction tank (hereinafter referred to also as "flocculation tank") may be either of a one-tank type or of a two or more-tank type.

[0026]

A flocculation treatment apparatus ordinarily contains a rapid stirring tank for allowing the flocculant to sufficiently be in contact with the water to be treated and a slow stirring tank for allowing flocculation flocs to grow. It is desirable that stirring by aeration according to the invention is conducted in the rapid stirring tank and a stable growth of flocs is realized by stirring without using the aeration in the next slow stirring tank. Therefore, when the two or more flocculation tanks are provided, the flocculation tank in the former step is set to be an aeration tank by air and that in the latter step is set to be a mechanical stirring tank.

[0027]

An amount of air to be aerated in the aeration tank by air is not particularly limited and any amount is permissible so long as the flocculant can sufficiently be mixed. The aeration tank by air may simultaneously use mechanical stirring.

[0028]

<Flocculant>

Examples of flocculants to be used in the aeration tank by air include iron compound type flocculants such as ferric chloride, and polyferrous sulfate; and aluminum compound type flocculants such as aluminum sulfate, aluminum chloride and polyaluminum chloride and, from a flocculation effect side,

the iron compound type flocculants are preferred. These inorganic flocculants may be used singly or in combination with two or more types.

[0029]

An amount of the inorganic flocculant to be added is, although depending on the nature or quality of the biologically treated water, ordinarily preferably in the range of from about 50 to about 300 mg/L.

[0030]

Further, by simultaneously using an organic flocculant and, a flotation agent in accordance with the nature of the wastewater, improvement of water quality of the water subjected to flocculation treatment or an improvement effect of the dissolved air flotation separation ability can be obtained. On this occasion, the organic flocculant may be added in the former step, in the latter step, or in the adding step of the inorganic flocculant of the inorganic flocculant addition process.

[0031]

An amount of the organic flocculant to be added is, although depending on water quality of the biologically treated water or a state of usage of the organic flocculant, ordinarily preferably in the range of from about 1 to about 10 mg/L.

[0032]

<pH adjustment>

pH at the time of flocculation treatment is preferably in the range of from 3 to 6 in the flocculation tank which performs aeration stirring. By adjusting pH to be in an acidic side in this manner, the flocculation treatment effect can be enhanced. Particularly, when the iron compound type flocculant is used, mixing at a pH value of 5.5 or less by aeration stirring is effective and, when the aluminum compound type flocculant is used, after mixing is performed at a pH value of 5.5 or less by aeration stirring, it is effective to readjust pH to be 6.0 or more.

[0033]

When the flocculation treatment apparatus contains a flocculation tank made up of two or more tanks, the flocculation tank may be arranged such that pH of at least one tank of two or more tanks which perform stirring by aeration is adjusted to be in the range of from 3 to 6, while pH of each of other tanks thereof is adjusted to be in the range of other than from 3 to 6.

[0034]

For adjusting pH, acids such as hydrochloric acid (HCl), and sulfuric acid (H_2SO_4); and alkalis such as sodium hydroxide (NaOH) can appropriately be used.

[0035]

<Oxidant>

As described above, in the flocculation treatment

process, it is preferable to add an oxidant and, by this action, a more favorable effect can be obtained.

[0036]

As for such oxidants, one type or two or more types of, for example, sodium hypochlorite (NaClO) and sodium persulfate can be used and an amount thereof to be added is, although depending on a water quality or flocculation treatment conditions of the biologically treated water, ordinarily preferably in the range of from about 1 to about 10 mg/L.

[0037]

Dissolved air flotation separation

Water subjected to flocculation treatment is next subjected to dissolved air flotation separation and flocculation flocs thus generated are subjected to solid-liquid separation.

[0038]

For this dissolved air flotation separation, an ordinary dissolved air flotation separator can be used.

[0039]

According to the invention, by performing aeration in the flocculation treatment, the dissolved air flotation separation ability of the water subjected to flocculation treatment is improved and, by such improvement, water feed LV at the time of the dissolved air flotation separation can be increased from 4 to 7 hr^{-1} which is a water feed LV at the time

of ordinary dissolved air flotation separation into 10 to 20 hr^{-1}. Accordingly, improvement of treatment efficiency and reduction of installation space of the apparatus due to reduction of the size thereof can be realized.

[0040]

Filtration

It is preferable that the separation water obtained by the dissolved air flotation separation is further subjected to filtration by a filtration apparatus. As for such filtration apparatuses, a filled-layer type filtrating unit in which a filtering material such as sand or anthracite is filled; or a membrane filtration unit using a membrane such as, a microfiltration (MF) membrane, or an ultrafilter (UF) membrane can be used.

[0041]

According to the invention, since water, having a good water quality, subjected to the dissolved air flotation separation can be obtained by improving the dissolved air flotation separation ability by performing aeration at the time of flocculation treatment, frequency of the cleaning of the filtration apparatus can be reduced by preventing clogging of pores of this filtration apparatus and, accordingly, improvement of the treatment efficiency can be realized.

[0042]

RO membrane treatment

The water subjected to the dissolved air flotation separation or further subjected to the filtration treatment may be allowed to supply to the RO membrane separator, that is, subjected to the RO membrane treatment and, by a deionized treatment by the RO membrane treatment, highly-purified water can be obtained.

[0043]

On this occasion, prior to the RO membrane treatment, in order to remove SS remained in water subjected to the dissolved air flotation separation, it is preferable that the water subjected to the dissolved air flotation separation is subjected to filtration treatment by allowing it to feed to the filtration apparatus. However, the water subjected to the dissolved air flotation separation may be directly subjected to the RO membrane treatment.

[0044]

As for such RO membrane separators, any known apparatus can be used.

[0045]

According to the invention, favorable water subjected to the dissolved air flotation separation can be obtained with a small amount of inorganic flocculant to be added and, further, the water further subjected to the filtration treatment has a low FI value and, since the water can be supplied to the RO membrane separator, lowering of membrane flux by fouling of

the RO membrane separator is suppressed and, then, the treated water (permeated water) can be obtained consistently for long period of time.

[0046]

Further, the FI value is used as an indicator for judging whether the quality of water supplied to the RO membrane separator is appropriate or not for the RO membrane treatment when deionization treatment is performed by allowing the water to pass through the RO membrane separator. When an amount of dissolved organic material or SS in the water which is allowed to pass through the RO membrane separator is almost same, there are cases in which a membrane flux is decreased at an early stage and it is not decreased, respectively. The FI value of the quality of the water supplied to the RO membrane separator is different between these cases.

[0047]

As described in water evaluations in embodiments below, a sample water is allowed to pass through a membrane filter having a given pore size and, then, an amount of time required for allowing a given amount of water to pass therethrough is measured and, thereafter, the FI value is measured from an amount of time required at an early stage and that after a given amount of time and is used for evaluation as to whether the water quality tends to cause a membrane fouling or a membrane clogging or not. There is a case in which, even when the FI

value of the water quality is 5 or less, the water is accepted as appropriate supply water for the RO membrane separator but, ordinarily, the water quality having an FI value of 4 or less is preferred. Therefore, according to the invention, the biologically treated water is subjected to the flocculation treatment and dissolved air flotation separation and, preferably, further to the filtration treatment, to thereby obtain water having an FI value of 4 or less. It is preferable that the thus-obtained water is, then, subjected to the RO membrane treatment.

[0048]

Other treatments

Further, according to the invention, at a latter step of the dissolved air flotation separator, other treatments than those described above may simultaneously be used. For example, in order to remove a remaining dissolved organic material, an activated carbon tower is provided and, then, an adsorption treatment by the activated carbon may be performed.

[0049]

On this occasion, the activated carbon tower is preferably provided in the latter step of the filtration apparatus and in the former step of the RO membrane separator.

[0050]

Treatment apparatus

An example of wastewater treatment apparatus according

to the invention is described with reference to accompanying drawings.

[0051]

FIGS. 1 to 5 each show an example of flow chart of the wastewater treatment apparatus according to the invention. In these drawings, the reference number 1 denotes a biological reaction tank; the reference numbers 2, 2A, 2B and 2C each denote a flocculation tank; the reference number 3 denotes a dissolved air flotation separator; the reference number 4 denotes a filtration apparatus; and the reference number 5 denotes an RO membrane separator; and the reference number 6 denotes an activated carbon tower.

[0052]

In the wastewater treatment apparatus in FIG. 1, after wastewater is biologically treated in the biological reaction tank 1, it is added with an inorganic flocculant (for example, iron compound type flocculant), an oxidant and an acid in a first flocculation tank 2A equipped with an aeration unit and subjected to flocculation treatment with a rapid stirring under a condition of pH of from 3 to 6 and, then, introduced into a second flocculation tank 2B equipped with a stirrer and added with an organic flocculant and an alkali and, then, subjected to the flocculation treatment with a slow stirring under a condition of pH of from 5 to 8. The water subjected to the flocculation treatment is next subjected to the dissolved air

flotation separation in the dissolved air flotation separator 3 and the resultant separated water is filtered in the filtration apparatus 4 and, then, the resultant filtered water is taken out as treated water.

[0053]

In an apparatus shown in FIG. 2, an RO membrane separator 5 is further provided in the latter step of the filtration apparatus 4 shown in FIG. 1. The water subjected to the filtration treatment in a same manner as in the apparatus shown in FIG. 1 is further subjected to the deionization treatment in the RO membrane separator 5 and, then, taken out as treated water.

[0054]

In an apparatus shown in FIG. 3, an activated carbon tower 6 is provided between the filtration apparatus 4 and the RO membrane separator 5 of the apparatus shown in FIG. 2 and, then, an inorganic flocculant (for example, aluminum compound type flocculant), an oxidant, and an acid or alkali are added in the first flocculation tank 2A and only an acid or alkali in the second flocculation tank 2B. As to the water subjected to the flocculation treatment, the dissolved air flotation separation and the filtration treatment in a same manner as in a case in FIG. 1, after the remaining dissolved organic material is removed by the activated carbon tower 6, it is further subjected to the deionization treatment in the RO

membrane separator 5 and, then, taken out as treated water.

[0055]

In an apparatus shown in FIG. 4, the flocculation tank of the apparatus shown in FIG. 2 is allowed to be made up of one tank and, in the flocculation tank 2 provided with an aeration unit thereof, an inorganic flocculant, an oxidant, and an acid or alkali are added and, then, the water is subjected to the flocculation treatment under a condition of mild acidic pH and, thereafter, subjected to the dissolved air flotation separation in the dissolved air flotation separator 3, the filtration treatment and the RO membrane separation treatment and, then, taken out as treated water.

[0056]

In an apparatus shown in FIG. 5, the flocculation tank of the apparatus shown in FIG. 1 is allowed to be made up of three tanks and the biologically treated water is added with an organic flocculant and an acid or alkali in the first flocculation tank 2A equipped with a mechanical stirrer and, then, subjected to the flocculation treatment under a condition of pH of from 5 to 7 and, then, added with an inorganic flocculant, an oxidant, and an cid or alkali in the second flocculation tank 2B with aeration stirring under a condition of pH of from 3 to 6 and, further, added with an acid or alkali in the third flocculation tank 2C with mechanical stirring under a condition of pH of from 6 to 8 and the resultant water subjected to the

flocculation treatment is, then, subjected to the dissolved air flotation separation and filtration treatment and, then, taken out as treated water.

[0057]

Further, apparatuses shown in FIGS. 1 to 5 are mere examples of wastewater treatment apparatuses according to the invention. The invention should not be construed as being limited to these examples and, as described above, various types of other embodiments can be adopted in the flocculation tanks, treatment apparatuses in the latter step and the like.

[Examples]

[0058]

The present invention is specifically described with reference to Examples and Comparative Examples.

[0059]

Examples 1 to 4

By using an apparatus shown in FIG. 1, organic wastewater was treated according to the invention. Water quality of the treated organic wastewater, and specifications and operational conditions of a biological reaction tank, a flocculation tank and the like which have been used are described below. Treatment was performed with a treatment amount of 2400 L/day.

[0060]

Separation water of an dissolved air flotation separator

was collected and, then, evaluation of the water quality of the treated water was performed based on an FI value computed as described below from filtration time consumed when the separation water was filtered with a filter of 0.45 μm under a pressure condition of 2.1 kg/cm^2, and a filtration continuous time in the filtration apparatus (time duration capable of continuously performing filtration until the filtration apparatus is clogged and cleaning becomes necessary). The results are shown in Table 1.

[0061]

As described above, standard of water feed into the RO membrane separator is an FI value of 4 or less and it is preferable that the treated water having a FI value of 4 or less can be obtained.

$FI=\{(1-T_0/T_{15})/T_{15}\}100$,

wherein T_0 represents time duration (sec) needed for filtering initial 500 cc of water; and

T_{15} represents time duration (sec) needed for filtering 500 cc of water after a continuous filtering time of 15 min.

[0062]

Water quality of organic wastewater

BOD: 1000 mg/L

[0063]

Biological reaction tank

Tank capacity: 2400 L

Aeration amount: 200 L/min

Carrier: addition of sponge of 3 mm cube up to 50% (in terms of the apparent capacity) of the tank capacity.

[0064]

First flocculation tank

Tank capacity: 50 L

Inorganic flocculant: addition of 200 mg/L (in terms of $FeCl_3$) of 38% by weight aqueous solution of ferric chloride

Oxidant: addition of sodium hypochlorite with weight defined in Table 1

pH in tank: as shown in Table 1 (adjusted with HCl or NaCl)

Aeration amount by air: 20 L/min

[0065]

Second flocculation tank

Tank capacity: 50 L

Organic flocculant: addition of 0.5 mg/L of partially hydrolysed polyacrylamide

pH in tank: as shown in Table 1 (adjusted with HCl or NaOH)

Stirrer: flat blade: 40 mmx200 mm; paddle stirring: 60 rpm

[0066]

Dissolved air flotation separator

Tank: cylindrical dissolved air flotation separator

having a diameter of 130 mm

Ratio of pressured water: 30%

Water feed LV: 10 m/hr

[0067]

Filtration apparatus

Filtration method: gravitational 2-layer filtration

Filtration LV: 5.6 m/hr

[0068]

Comparative Example 1

A treatment was performed in a same manner as in Example 1 except that a stirring unit of the first flocculation tank did not adopt the aeration by air but adopted the paddle stirring in a same manner as in the second flocculation tank. Treatment results are shown in Table 1.

[0069]

Comparative Example 2

A treatment was performed in a same manner as in Comparative Example 1 except that an amount of inorganic flocculant to be added in the first flocculation tank was increased as shown in Table 1. Treatment results are shown in Table 1.

[0070]

[Table 1]

		Example				Comparative Example	
		1	2	3	4	1	2
First flocculation tank	Amount of Inorganic flocculant ($FeCl_3$) to be added (mg/L)	200	200	200	200	200	450
	Amount of Oxidant (NaClO) to be added (mg/L)	10	10	10	-	10	10
	pH	5.5	3.0	7	5.5	5.5	5.5
	Stirring method	Aeration by air				Mechanical stirring	
Second flocculation tank pH		5.5	7	5.5	5.5	5.5	5.5
Treated water FI		2.0	2.1	3.0	3.3	5.6	3.8
Filtration continuous time duration (hr)		24	24	24	24	17	10

[0071]

From Table 1, findings are as described below.

[0072]

Namely, in Comparative Example 1 in which the treatment was performed by using the mechanical stirring in the first flocculation tank, the FI value of the treated water was high and the water quality was inferior. Further, filtration continuous time duration was shorter than Examples 1 to 4. In Comparative Examples 2 in which an amount of the inorganic flocculant to be added was increased, the FI value was improved but not sufficiently. Further, neither of formation of the flocculation flocs nor affinity of the flocs with bubbles is sufficient and, then, the dissolved air flotation separation ability was inferior and, therefore, the filtration continuous time duration was extremely short.

[0073]

On the other hand, in Examples 1 to 4 in each of which aeration by air was conducted in the first flocculation tank, favorable results were unanimously obtained and, particularly, in the case in which the oxidant was used (Example 3), and, further, in the cases in each of which pH in the first flocculation tank was allowed to be in an acidic region (Examples 1, 2), favorable results were obtained.

[0074]

Example 5

A treatment was performed in a same manner as in Example 1 except that PAC (polyaluminum chloride) was used as an inorganic flocculant to be added in the first flocculation tank and an amount thereof to be added was set to be 250 mg/L and, further, pH values in the first flocculation tank and the second flocculation tank were set to those as shown in Table 1, respectively. Treatment results are shown in Table 2.

[0075]

Comparative Example 3

A treatment was performed in a same manner as in Example 5 except that a stirring unit of the first flocculation tank did not adopt the aeration by air but adopted the paddle stirring in a same manner as in the second flocculation tank. Treatment results are shown in Table 2.

[0076]

[Table 2]

		Example 5	Comparative Example 3
First flocculation tank	Amount of inorganic flocculant(PAC) to be added (mg/L)	250	250
	Amount of oxidant (NaClO) to be added (mg/L)	10	10
	pH	6.0	6.0
	Stirring method	Aeration by air	Mechanical stirring
Second flocculation tank pH		6.0	6.0
Treated water FI		3.9	6.0
Filtration continuous time duration (hr)		17	10

[0077]

From Table 2, it is found that, even when PAC was used as the inorganic flocculant, the effect of the invention which uses aeration by air was obtained. Further, when Example 5 and Comparative Example 3 were compared with each other, the FI value in Example 5 was more favorable than that in Comparative Example 3 and the filtration continuous time duration in Example 5 was longer than that in Comparative Example 3.

Brief Description of the Drawings

[0078]

FIG. 1 is a flow chart showing an embodiment of a wastewater treatment apparatus according to the present invention;

FIG. 2 is a flow chart showing another embodiment of a wastewater treatment apparatus according to the present

invention; and

FIG. 3 is a flow chart showing further another embodiment of a wastewater treatment apparatus according to the present invention;

FIG. 4 is a flow chart showing still further another embodiment of a wastewater treatment apparatus according to the present invention; and

FIG. 5 is a flow chart showing even still further another embodiment of a wastewater treatment apparatus according to the present invention.

Description Of Reference Numerals And Signs

[0079]

1	biological reaction tank
2	flocculation tank
2A	first flocculation tank
2B	second flocculation tank
2C	third flocculation tank
3	dissolved air flotation separation tank
4	filtration apparatus
5	RO membrane separator
6	activated carbon tower

In the drawings, from left to right, and from top to bottom.

FIG. 1

WASTEWATER

BIOLOGICAL REACTION TANK

OXIDANT

INORGANIC FLOCCULANT

ACID

FIRST FLOCCULATION TANK

(AERATION BY AIR)

ALKALI

ORGANIC FLOCCULANT

SECOND FLOCCULATION TANK

(MECHANICAL STIRRING)

DISSOLVED AIR FLOTATION SEPARATION TANK

FILTRATION APPARATUS

TREATED WATER

FIG. 2 (4)

RO MEMBRANE SEPARATOR

FIG.3 (6)

ACTIVATED CARBON TOWER

FIG. 5 (2C)

THIRD FLOCCULATION TANK

Claims

1. A wastewater treatment apparatus, comprising:

a biological reaction tank for biologically treating water to be treated;

a flocculation reaction tank for conducting a flocculation reaction by adding a flocculant to the thus-biologically treated water flowing from the biological reaction tank; and

a dissolved air flotation separator for performing solid-liquid separation on the water subjected to a flocculation treatment flowing from the flocculation reaction tank,

wherein an aeration unit is provided in the flocculation reaction tank.

2. The wastewater treatment apparatus according to Claim 1, further comprising a pH control agent addition unit for adding a pH control agent for adjusting pH of water in the flocculation reaction tank to be in the range of from 3 to 6.

3. The wastewater treatment apparatus according to Claim 1 or 2, further comprising an oxidant addition unit for adding an oxidant into the flocculation reaction tank.

4. The wastewater treatment apparatus according to any one of Claims 1 to 3, further comprising a filtration apparatus which performs the solid-liquid separation on the water subjected to the dissolved air flotation separation flowing from the dissolved air flotation separator.

5. A wastewater treatment method, comprising:

a biological reaction step for biologically treating water to be treated;

a flocculation reaction step for conducting a flocculation reaction by adding a flocculant to biologically treated water flowing from the biological reaction step; and

a dissolved air flotation separation step for performing solid-liquid separation on the water subjected to a flocculation treatment flowing from the flocculation reaction step, wherein a flocculation reaction in the flocculation reaction step is conducted under aeration.

6. The wastewater treatment method according to Claim 5, wherein a pH control agent is added to water in the flocculation reaction step for adjusting a pH value of the water to be in the range of from 3 to 6.

7. The wastewater treatment method according to Claim 5 or 6, wherein an oxidant is added to water in the flocculation

reaction step.

8. The wastewater treatment method according to any one of Claims 5 to 7, further comprising a filtration step for performing the solid-liquid separation on the water subjected to the dissolved air flotation separation flowing from the dissolved air flotation separation step.