[0004]

In order to realize the advanced wastewater treatment of the industrial wastewater, technologies of treating wastewater by combining the oxidation reaction or the photochemical reaction by ultraviolet light have been proposed. Japanese Patent Application Laid-open No. 2015-128751 (Patent Literature 1 below) discloses wastewater treatment which is a combination of the biological treatment with Fenton treatment which is oxidation treatment.

[0005]

Further, ozone oxidation is a more general technology in the advanced treatment of the terminal water by the biological treatment of the industrial wastewater. However, when the ozone oxidation technology is used alone, treatment cost is frequently increased to realize the advanced treatment of the industrial wastewater. For this reason, the combination of the ozone oxidation technology with the biological treatment has been studied to reduce the treatment costs. Japanese Patent Application Laid-open No. 2015-226889 (Patent Literature 2 below) discloses treatment of a liquid containing an amine-based organic compound, obtained by combining the oxidation treatment for introducing an oxidizing agent to decompose the amine-based organic compound with the biological treatment, and discloses that ozone is used as the oxidizing agent.

CITATION LIST

PATENT LITERATURES

[0006]

Patent Literature 1: Japanese Patent Application Laid-open No. 2015-128751

Patent Literature 2: Japanese Patent Application Laid-open No. 2015-226889

SUMMARY OF INVENTION

TECHNICAL PROBLEMS

[0007]

However, the Fenton treatment utilized in the above-mentioned Patent Literature 1 requires much time and labor because it has an increased number of processes. On the other hand, since the ozone oxidation treatment utilized in the above-mentioned Patent Literature 2 has low solubility of ozone in water and weak oxidizing ability of ozone, the ozone oxidation treatment has drawbacks such as a slow mass transfer rate between gas and liquid and low ozone utilization efficiency. Further, in Patent Literature 2, since the ozone oxidation treatment is carried out at a pH significantly different from the subsequent biological treatment, a process of adjusting the pH at the time of shifting to the biological treatment is necessary, and the treatment cost is increased. Furthermore, even when unused ozone is discharged from wastewater, the ozone utilization efficiency is lowered.

[0008]

Further, in any of the above-described wastewater treatments, aeration is performed in order to activate treatment with aerobic microorganisms. However, the aeration of wastewater requires power, and, from the viewpoint of energy consumption, it is preferred to perform the wastewater treatment without using the aeration.

[0009]

The present disclosure has been made in view of the above-described problems, and it is an object of the present invention to provide a wastewater treatment device and a wastewater treatment method capable of preventing an inhibition of biological treatment while enjoying advantages of wastewater treatment by ozone oxidation, reducing wastewater treatment costs, and realizing excellent treatment by a simple process.

SOLUTION TO PROBLEMS

[0010]

According to an aspect of the present disclosure, a wastewater treatment device is summarized to include: an ozone generator which supplies ozone; a mixer which mixes ozone supplied from the ozone generator with wastewater and supplies ozone mixed wastewater; an ozone oxidation unit which progresses ozone oxidation in the ozone mixed wastewater while passing the ozone mixed wastewater therethrough and discharges wastewater in which the ozone has been consumed; a biological treatment unit which has microorganisms for biological treatment and performs the biological treatment on the wastewater discharged from the ozone oxidation unit using the microorganisms; and an adjusting device which adjusts the amount of ozone to be mixed with the wastewater by the mixer so that ozone in an amount that inhibits the microorganisms of the biological treatment unit does not remain in the wastewater discharged from the ozone oxidation unit.

[0011]

It is suitable that the adjusting device includes: a measuring device which measures the amount of ozone in the wastewater discharged from the ozone oxidation unit; and a regulating valve capable of regulating the amount of ozone to be mixed with the wastewater by the mixer, and the regulating valve is adjusted based on the measurement by the measuring device in such a manner that the amount of ozone in the wastewater is lower than a level at which the microorganisms are inhibited.

[0012]

The wastewater treatment device may further include: a release passage for avoiding the supply of the wastewater to the biological treatment unit when the ozone remains in the wastewater discharged from the ozone oxidation unit; and a control valve which stops the supply of the wastewater to the biological treatment unit when the amount of ozone in the wastewater is equal to or higher than the

return passage which is configured to be able to indirectly supply the wastewater discharged from the ozone oxidation unit to the mixer via a wastewater source.

[0024]

The concentration of ozone that inhibits microorganisms is changed depending on the type and growth state of the used microorganisms, the contact time with ozone, or the like. If the contact time is long, the microorganisms are inhibited at a low ozone concentration. For example, nitrification activity is maintained to about 20 mg O_3/gSS for a short time contact in batch treatment using activated sludge, whereas in continuous treatment using microorganisms obtained by ozone acclimatization and preferential breeding of the activated sludge, there is little influence to about 6 mg O_3/gSS. Therefore, the level of the ozone concentration that inhibits microorganisms is set by investigating ozone resistance in the microorganisms to be used in advance.

[0025]

When the ozone amount in wastewater is higher than or equal to the level that inhibits microorganisms, it is necessary to lower the mixed amount of ozone. As the adjusting device for adjusting the mixed amount of ozone, a measuring device for measuring the amount of ozone in the wastewater discharged from the ozone oxidation unit, and a regulating valve capable of regulating the amount of ozone which is supplied from the ozone generator to the mixer and mixed with the wastewater are provided. The regulating valve is controlled so that the amount of ozone to be mixed with the wastewater is reduced based on the measured value of the ozone amount in the wastewater by the measuring device. At this time, if the mixing ratio of ozone in the mixer is reduced corresponding to the difference in ozone concentration between the measured value of the ozone amount in the wastewater and the level inhibiting the microorganisms, the mixing ratio of ozone in the mixer can

efficiently approximate an appropriate value and the time required for the adjustment can be shortened.

[0026]

In the case of avoiding the supply of wastewater to the biological treatment unit, the control to suppress the supply of wastewater to the biological treatment can be made by using a control valve which can stop the supply of wastewater according to the situations of the wastewater after subjecting to the ozone oxidation treatment. Specifically, the ozone amount in the wastewater discharged from the ozone oxidation unit is measured using the measuring device, and, based on the measured value, the supply of wastewater to the biological treatment unit is stopped by the control valve when the ozone amount in the wastewater is higher than or equal to the level that inhibits microorganisms. The ozone dissolved in the wastewater is decomposed in a relatively short time, but even a small amount of ozone may inhibit microorganisms. Thus, in the conventional wastewater treatment technology, bubbling or the like is used, which promotes the release of ozone to the atmosphere. In the present disclosure, the supply to the biological treatment may be avoided only when the concentration of ozone in the wastewater is at the level that inhibits microorganisms. For the wastewater which is not supplied to the biological treatment, the supply destination of the wastewater is switched, and thus the wastewater can be supplied by the return passage to the mixer directly or indirectly via the wastewater source. The returned wastewater is prepared again as the ozone mixed wastewater, and the ozone oxidation treatment is repeated. In the supply switching of the wastewater, it is suitable to provide an on-off valve that can intermittently direct the flow between the ozone oxidation unit and the biological treatment unit, and to operate it synchronously so that the supply of wastewater is stopped when the on-off valve is closed. Alternatively, the release passage (return

passage) may be configured to be branched from a flow channel through which the wastewater is discharged from the ozone oxidation unit, and a direction control valve is provided at a branch point to switch the flow channel that communicates. As a modified example, the release passage branched from the flow channel through which the wastewater is discharged from the ozone oxidation unit can be configured as a bypass path L6’ and thus an ozone decomposing device D can be provided on the bypass path (see Fig. 4). The wastewater discharged from the ozone oxidation unit is temporarily prevented from being supplied to the biological treatment unit by a switching valve V19 and the ozone remaining in the wastewater is decomposed by the ozone decomposing device. This wastewater can be supplied to the biological treatment unit. The ozone decomposing device may be according to any of methods such as adsorption decomposition method, heating decomposition method, catalytic decomposition method using alumina, silica or the like. In the case of using an ozone decomposing apparatus D’ according to the heating decomposition method, the ozone decomposing apparatus D’ may be configured to be provided on the channel L6 as shown in Fig. 5 to perform the decomposition by detecting ozone using an ozone meter S6.

[0027]

In the ozone oxidation of the wastewater, as the amount of organic pollutants is increased, the amount of ozone required for ozone oxidation is increased. However, excessive ozone increases the residual ozone amount of the wastewater after the ozone oxidation, and also decreases the ozone utilization efficiency in the ozone oxidation. In the evaluation using COD (chemical oxygen demand) as an index of organic pollutant concentration, when ozone is mixed with wastewater so that the ozone/COD ratio is about 0.67 or less, the ozone utilization efficiency of about 97.5% or more can be achieved and the amount of ozone

be generally set so that the ozone/COD ratio is in a range of about 3 mg/mg or less, and wastewater whose COD is excessively high may be diluted in advance with treated wastewater or the like as necessary. Therefore, in a simple manner, the supply flow rate of ozone may be adjusted, depending on the water quality (for example, COD) of the wastewater and the flow rate of the wastewater supplied to the ozone oxidation treatment, so that the mixing ratio of ozone falls within the above-described appropriate range. In wastewater that is subjected to the ozone oxidation at the appropriate mixing ratio, persistent organic substances are satisfactorily decomposed and thus the burden of microorganisms in the subsequent biological treatment is reduced, so that the microorganisms in the biological treatment well consumes easily decomposable organic substances. By the ozone oxidation, the decomposition and removal of the organic pollutants can generally be achieved at a removal rate of about 20 to 30% in terms of COD.
[0030]

Ozone can be mixed with wastewater using a common gas-liquid mixer. In order to promote dissolution of ozone, subdivision and pressurized supply are effective. Therefore, in preparing the ozone mixed wastewater, it is preferable to bubble ozone using a bubble generator and to disperse the ozone in wastewater in the form of fine bubbles. The bubbling of ozone can be carried out by a mixer which mixes gas with a liquid by a gas-liquid shearing method, a foaming device which ejects gas into a liquid from a minute ejection orifice, and an inline mixer (static mixer) which directly introduces gas into a flowing liquid, and the like. It may be appropriately selected and used from the instruments or devices as described above. From the viewpoint of the reaction control and the precision management, it is suitable that there are few variations in the size of bubbles. Further, when the bubbles are small, the gas-liquid contact area per volume becomes large, and

thus ozone becomes easy to dissolve in water. At the same time, the floating speed of bubbles is small and thus a residence time in water can be increased. Therefore, it is easy to increase the utilization efficiency of ozone. For this reason, it is convenient to use the microbubble generator as the mixer. Microbubbles usually mean fine bubbles having a diameter of about 10 to 50 μm. As described above, the microbubbles can significantly improve the gas-liquid mass transfer rate and transfer efficiency. Therefore, the supply of ozone using the microbubble generator can improve the mass transfer and utilization efficiency of ozone in the ozone oxidation treatment, and can greatly improve its effectiveness.

[0031]

Since ozone easily reacts with organic compounds having a double bond, an activated aromatic group, an amino group, a sulfur-containing group or the like and generates hydroxy radicals by the reaction, the ozone oxidation relatively easily proceeds in industrial wastewater. However, in order to efficiently progress the wastewater treatment, it is preferable to promote the ozone oxidation reaction. The ozone oxidation is promoted by addition of hydrogen peroxide, ultraviolet irradiation, or coexistence of a catalyst, whereby hydroxyl radicals or ozonide ions generated from ozone contribute to the acceleration of oxidation. Therefore, if the promoting means as described above is used in the ozone oxidation treatment, the treatment efficiency can be improved and the treatment time can be shortened, which is useful for advanced treatment of industrial wastewater. In particular, the use of the catalyst is effective to reduce the treatment cost in long-term continuation of wastewater treatment. There are a homogeneous catalyst and a heterogeneous catalyst as the catalyst. When the heterogeneous catalyst is used, it is easy to separate the catalyst which is in contact with wastewater. For the above-mentioned reason, it is

by ordinary aeration. Therefore, since the aeration is unnecessary in the biological treatment, energy consumption accompanying the aeration can be eliminated and the cost of wastewater treatment can be reduced. In addition, with supplying a high concentration of oxygen, it is possible to increase a filling amount of aerobic microorganisms for the biological treatment and increase the treatment efficiency, which is also advantageous in this respect.

[0034]

The biological treatment can proceed using the aerobic microorganisms commonly used for the biological treatment of organic wastewater, and examples of the aerobic microorganisms include aerobic microorganisms constituting activated sludge. Using oxygen generated from ozone, the aerobic treatment can be performed in wastewater without performing the aeration. By the aerobic treatment, a nitrogen component such as amines is converted into ammonia nitrogen and nitrate nitrogen, a carbon component is converted into carbon dioxide and water, and a sulfur component is converted into sulfate. In a treatment according to the activated sludge method, anaerobic biological treatment proceeds in anoxic state after the aerobic biological treatment. Where the microorganisms used for the biological treatment contain similar anaerobic microorganisms (or microorganisms having both aerobic and anaerobic properties), aerobic treatment and anaerobic treatment can be carried out. In that case, nitrate nitrogen is converted to nitrogen gas.

[0035]

From the viewpoint of continuously treating the wastewater, treatment using a biofilm is carried out in the biological treatment, in order to efficiently perform the contact and separation between the wastewater and the microorganisms. The biofilm is formed by carrying microorganisms on a carrier according to methods such as a rotating biological contact method, a trickling filter

method, a catalytic oxidation method, an aerobic filter bed method, and the like. Using a porous body, a fiber material or the like as a carrier, the biological bed to be used can be formed by using the carrier and having microorganisms formed on the surface thereof. It is efficient to construct a biological treatment unit in a multistage structure composed of a plurality of biological beds. The biological bed (biological filter) formed in a filter shape using a layered fiber material as the carrier can be handled conveniently.

[0036]

In this way, by combining the ozone oxidation treatment with the biological treatment, the supply of wastewater after the ozone oxidation treatment is controlled so that the microorganisms in the biological treatment are not inhibited, whereby the industrial wastewater is possibly treated stably and continuously. The ozone utilization rate in the ozone oxidation is high, and the persistent organic substances can be efficiently decomposed by using the oxidation ability of ozone. And the biological treatment can efficiently proceed by utilizing the high-concentration oxygen generated from ozone.

[0037]

An embodiment of a wastewater treatment device capable of carrying out the wastewater treatment as described above will be described below with reference to the drawings. A wastewater treatment device 10 shown in FIG. 2 includes an ozone generator 1, a microbubble generator 2, a suction pump 3, an ozone oxidation unit 4, and a biological treatment unit 5. In this embodiment, the microbubble generator 2 is adopted as the mixer, but it is not limited to this adoption, and a common gas-liquid mixer may be used. The ozone oxidation unit 4 is configured as an airtight pressure vessel and has a plurality of catalyst beds C in which a heterogeneous catalyst for ozone oxidation reaction is supported, and it has a multistage

structure in which the plurality of catalyst beds C are stacked in the vertical direction. Inside the biological treatment unit 5, a biological bed B having a biofilm on its surface is disposed. Wastewater W is stored in a wastewater tank 6 (wastewater source), and treated water W' discharged from the biological treatment unit 5 is stored in a post-treatment water tank 7.

[0038]

The ozone generator 1 is connected to the microbubble generator 2 through a flow channel L1, and the microbubble generator 2 is connected to the suction pump 3 through flow channels L2, L3, and L4, and further connected to a bottom inlet of the ozone oxidation unit 4 through a flow channel L5. An upper end of the ozone oxidation unit 4 is connected to the bottom part of the biological treatment unit 5 by a flow channel L6.

[0039]

The ozone generator 1 generates ozone, using pure oxygen as a raw material, and the ozone is introduced into the microbubble generator 2 through the flow channel L1. At the same time, the wastewater W pumped from the flow channel L2 by the driving of the suction pump 3 is also supplied to the microbubble generator 2 through the flow channel L3 and L4 and mixed with ozone. In the microbubble generator 2, the ozone mixed wastewater in which ozone is dispersed in a state of microbubbles is prepared. The ozone mixed wastewater flows into the ozone oxidation unit 4 from the bottom inlet through the flow channel L5. In addition, a flow channel L7 is provided to communicate a space above the catalyst bed C in the ozone oxidation unit 4 with the flow channel L4, and such a configuration in which wastewater can return from the ozone oxidation unit 4 to the microbubble generator 2 through the flow channel L7 is formed. In other words, the flow channel L7 functions as a return passage through which wastewater directly returns from the ozone oxidation unit 4 to the microbubble

generator 2.

[0040]

A flow rate control valve V1 capable of adjusting a flow rate of the wastewater W, a filter F1 for filtering the wastewater W, a flow meter S1 for detecting the flow rate of the wastewater W, and a one-way valve V2 for preventing a backflow of the wastewater W are provided on the flow channel L2. The flow rate control valve V1 is electrically connected to the flow meter S1 and is configured so that the flow rate in the flow channel L2 can be adjusted to a desired flow rate based on the flow rate detected by the flow meter S1. A flow rate control valve V3, a flow meter S2, a pressure sensor S3, and a one-way valve V4 for preventing backflow are provided on the flow channel L1. The flow rate control valve V3 is electrically connected to the flow meter S2 and is configured so that the flow rate of ozone in the flow channel L1 can be adjusted based on the flow rate detected by the flow meter S2. In addition, a flow rate control valve V5 and a flow meter S4 are provided on the flow channel L3 and are electrically connected to each other so that the flow rate of the wastewater W supplied from the wastewater tank 6 to the microbubble generator 2 is adjusted by the flow rate control valve V5, based on the flow rate detected by the flow meter S4. A filter F3, an on-off valve V17, and a flow meter S4′ are provided on the flow channel L4, and the flow rate of the flow channel L4 can be monitored by the flow meter S4′. A flow meter S5 and an on-off valve V6 are provided on the flow channel L5. An on-off valve V7 and a filter F2 are provided on the flow channel L6 and are configured to be able to switch the supply and stop of wastewater from the ozone oxidation unit 4 to the biological treatment unit 5. In addition, an on-off valve V8 and a one-way valve V12 are provided on the flow channel L7 and are configured to be able to switch the return and shutoff of wastewater from the ozone oxidation unit 4 to

the microbubble generator 2. In addition, an on-off valve V9 is provided on the flow channel L3, and the supply of the wastewater W to the microbubble generator 2 can be controlled by the on-off valve V9.

[0041]

In the above configuration, when the ozone generator 1 and the microbubble generator 2 are operated while the on-off valves V6, V9, and V17 are opened to drive the suction pump 3, the wastewater W and ozone are supplied to the microbubble generator 2 at flow rates in accordance with the mixing ratio of the initial setting and the ozone mixed wastewater is introduced into the bottom inlet of the ozone oxidation unit 4. The supplied ozone mixed wastewater rises from a bottom part toward a top part of the ozone oxidation unit 4, and sequentially passes through a plurality of catalyst beds C in the meantime, thereby the ozone oxidation is promoted by the contact with the catalyst. The wastewater in the ozone oxidation unit 4 can be discharged through the flow channel L6 or the flow channel L7 under pressure. The pressure inside the ozone oxidation unit 4 is monitored by a pressure sensor S11 provided at the top.

[0042]

As a measuring device which measures the amount of ozone in the wastewater that has passed through the catalyst bed C, an ozone meter S6 is provided above the catalyst bed C in the ozone oxidation unit 4 to detect the residual ozone. The ozone meter S6 is electrically connected to the on-off valves V7 and V9. When the remaining amount of ozone in the wastewater to be detected is at the level that inhibits microorganisms in the biological treatment unit 5, the on-off valves V7 and V9 are closed to make the wastewater return from the ozone oxidation unit 4 to the microbubble generator 2 and circulate between the microbubble generator 2 and the ozone oxidation unit 4. At the same time, the flow rate control

The volume ratio of gas/water in the microbubble generator was set to 1/10 and microbubbles were generated at a pre-tube pressure of 0.3 MPa or more, whereby wastewater in which ozone bubbles having a diameter of 50 μm or less were dispersed was stably prepared and supplied to the ozone oxidation unit (ozone/COD = 2.6 mg/mg). As a result of setting the residence time of wastewater in the ozone oxidation unit to be one hour and examining the water quality of the wastewater passing through the catalyst bed, the COD was reduced to about 200 mg/L, the BOD/COD was increased to 0.30, and the concentration of dissolved oxygen exceeded 23 mg/L. The COD load removal was 1.46 kg/(m^3·d). The ozone concentration of wastewater was about 2.5 mg/L, and the ozone utilization rate exceeded 95%.

[0059]

This wastewater was introduced into the biological treatment unit as it was, and after about 6 hours, the treated water overflowed from the biological treatment unit. As a result of examining the water quality of the treated water, the concentration of dissolved oxygen was 10 mg/L or more, and the COD concentration of the effluent treated water was stable and less than 100 mg/L.

[0060]

(Treatment Example E2)

Using the device of FIG. 2, wastewater having a COD of 137 mg/L was subjected to the following wastewater treatment. The catalyst bed arranged in the ozone oxidation unit was composed of activated carbon and the biological bed of the biological treatment unit 5 was configured of a biofilter having a biofilm of aerobic microorganisms formed on the surface thereof.

[0061]

Wastewater and ozone were supplied to the microbubble generator 2 at a mixing ratio of ozone and wastewater at which a ratio of ozone/COD was 0.4 mg/mg to prepare ozone mixed wastewater, and the prepared ozone mixed wastewater

CLAIMS

[Claim 1] A wastewater treatment device, comprising:

an ozone generator which supplies ozone;

a mixer which mixes ozone supplied from the ozone generator with wastewater and supplies ozone mixed wastewater;

an ozone oxidation unit which progresses ozone oxidation in the ozone mixed wastewater while passing the ozone mixed wastewater therethrough and discharges wastewater in which the ozone has been consumed;

a biological treatment unit which has microorganisms for biological treatment and performs the biological treatment on the wastewater discharged from the ozone oxidation unit using the microorganisms; and

an adjusting device which adjusts the amount of ozone to be mixed with the wastewater by the mixer so that ozone in an amount that inhibits the microorganisms of the biological treatment unit does not remain in the wastewater discharged from the ozone oxidation unit,

wherein the ozone oxidation unit has a catalyst that promotes an ozone oxidation reaction.

[Claim 2] The wastewater treatment device according to claim 1, wherein the adjusting device includes:

a measuring device which measures the amount of ozone in the wastewater discharged from the ozone oxidation unit; and

a regulating valve capable of regulating the amount of ozone to be mixed with the wastewater by the mixer,

and the regulating valve is adjusted based on measurement by the measuring device in such a manner that the amount of ozone in the wastewater is lower than a level at which the microorganisms are inhibited.

[Claim 3] The wastewater treatment device according to

claim 2, further comprising:

a release passage for avoiding the supply of the wastewater to the biological treatment unit when the ozone remains in the wastewater discharged from the ozone oxidation unit; and

a control valve which stops the supply of the wastewater to the biological treatment unit when the amount of ozone in the wastewater is equal to or higher than the level at which the microorganisms are inhibited, based on the measurement by the measuring device.

[Claim 4] The wastewater treatment device according to claim 3, wherein the release passage is a return passage capable of supplying the wastewater discharged from the ozone oxidation unit to the mixer, and the wastewater flows through the return passage when the supply of the wastewater to the biological treatment unit is stopped by the control valve.

[Claim 5] The wastewater treatment device according to any one of claims 1 to 4, wherein the mixer includes a bubble generator which mixes ozone with wastewater by means of gas-liquid shearing, and ozone is dispersed in the ozone mixed wastewater in a state of bubbles, and the ozone oxidation unit is configured of an airtight pressure resistant container which progresses ozone oxidation under pressure.

[Claim 6] The wastewater treatment device according to claim 5, wherein the bubble generator is a microbubble generator which generates fine bubbles having a bubble diameter of 10 to 50 μm.

[Claim 7] The wastewater treatment device according to claim 1, wherein the ozone oxidation unit is configured in a multistage structure in which a plurality of catalyst

beds on which the catalyst is supported are stacked in a vertical direction, and is configured so that the ozone mixed wastewater sequentially passes through the plurality of catalyst beds while being introduced from a bottom part of the ozone oxidation unit and rising toward a top part of the ozone oxidation unit.

[Claim 8] The wastewater treatment device according to claim 1, wherein a difference in height between the biological treatment unit and the ozone oxidation unit is provided so that a water level in the biological treatment unit is lower than that in the ozone oxidation unit, and the wastewater of the ozone oxidation unit is supplied to the biological treatment unit using a gravity action due to the difference in height.

[Claim 9] The wastewater treatment device according to claim 2, further comprising:

an ozone decomposing device which decomposes ozone remaining in the wastewater discharged from the ozone oxidation unit when ozone remains in the wastewater discharged from the ozone oxidation unit.

[Claim 10] The wastewater treatment device according to claim 1, wherein the catalyst comprises a heterogeneous catalyst selected from metal oxides, metal-supported oxides, platinum group metals, zeolites, and activated carbon,

wherein the metal oxides include Fe_2O_3, CoO, MoO_3, MnO_2, SiO_2, Al_2O_3 and TiO_2, and the metal-supported oxide include silica gel and titania on each of which a metal selected from Co, Cu, Pb, Ru, Pt and Pd is supported.

[Claim 11] A wastewater treatment method, comprising:

ozone generation that supplies ozone;

mixing preparation for mixing the ozone supplied by the ozone generation with wastewater to supply ozone mixed

wastewater;

ozone oxidation treatment in which ozone oxidation is allowed to proceed in the ozone mixed wastewater, using a catalyst that promotes an ozone oxidation reaction, to discharge the wastewater in which the ozone has been consumed; and

biological treatment in which the wastewater after the ozone oxidation treatment is biologically treated with microorganisms,

wherein an amount of ozone mixed with the wastewater in the mixing preparation is adjusted so that ozone in an amount that inhibits the microorganisms of the biological treatment does not remain in the wastewater discharged from the ozone oxidation treatment.

[Claim 12] The wastewater treatment method according to claim 11, wherein a ratio of ozone to be mixed with the wastewater is adjusted according to a flow rate of the wastewater supplied to the ozone oxidation treatment and water quality of the wastewater so that an appropriate amount of ozone is mixed with the wastewater in the mixing preparation.

[Claim 13] The wastewater treatment method according to claim 11 or 12, which is applied to an advanced treatment for treating industrial wastewater containing a persistent organic substance.