

Title of Invention: METHOD FOR BIOLOGICALLY TREATING ORGANIC WASTEWATER

Field of the Invention

[0001] The present invention relates to a method for biologically treating organic wastewater such as domestic wastewater, sewage, and wastewater from food factories and pulp factories and specifically relates to a method for biologically treating organic wastewater in which organic wastewater is passed through an aerobic first biological treatment tank in order to generate dispersed bacteria by using bacteria and first biologically treated water from the first biological treatment tank, which contains the dispersed bacteria, is subsequently introduced into an aerobic second biological treatment tank containing a fluidized-bed carrier so that animalcules prey upon the dispersed bacteria.

Background of the Invention

[0002] An activated sludge process, which is used for biologically treating organic wastewater, has been widely used in sewage treatment, industrial wastewater treatment, and the like since it enables, for example, treated water having high quality to be produced with low maintenance requirement. However, the activated sludge process requires a large area because an operation at a BOD volumetric loading rate of about 0.5 to 0.8 kg/m³/d is performed in the

activated sludge process. Furthermore, 20% of the amount of decomposed BOD is converted into bacterial cells, that is, sludge, which creates a need to treat a large amount of excess sludge.

[0003] A known example of high-load treatment of organic wastewater is a fluidized-bed method in which a carrier is used. In this method, an operation at a BOD volumetric loading rate of 3 kg/m³/d or more can be achieved. However, the amount of sludge generated in this method is about 30% of the amount of decomposed BOD, which is larger than the amount of sludge generated in an ordinary activated sludge process.

[0004] In Japanese Patent Publication 55-20649B, it is described that the amount of excess sludge can be reduced by treating organic wastewater with bacteria in a first treatment tank in order to oxidatively decompose organic substances contained in the wastewater and convert the organic substances into bacterial cells of non-flocculating bacteria and subsequently removing the bacterial cells by utilizing predation by sessile protozoa in a second treatment tank. Furthermore, in the above method, a high-load operation can be achieved and the treatment efficiency of the activated sludge process can be increased. There have been proposed various wastewater treatment methods in which predation by protozoa or metazoa, which are creatures

higher than bacteria, is utilized as described above.

[0005] Japanese Patent Publication 2000-210692A proposes countermeasures against the degradation of treatment performance due to fluctuations in the quality of raw water, which may occur in the treatment method described in Japanese Patent Publication 55-20649B. Specific examples of the countermeasures include "controlling fluctuations in the BOD of water to be treated to be within a range of plus or minus 50% of the median of the average concentration", "measuring the qualities of water contained in a first treatment tank and first treated water over time", and "adding a microbial preparation or seed sludge to the first treatment tank when the quality of the first treated water is poor".

[0006] Japanese Patent Publication 60-23832B proposes a method in which, when bacteria, yeast, actinomycetes, algae, fungus, or primary sedimentation sludge or excess sludge generated in wastewater treatment are preyed upon by protozoa or metazoa, the flock sizes of the above preys are reduced by performing an ultrasonic treatment or mechanical agitation so as to be smaller than the mouth of the protozoa or metazoa.

[0007] A method for biologically treating organic wastewater in which a multistage treatment using a fluidized bed and an activated sludge process in combination is

employed is described in Japanese Patent 3410699. In this method, the auto-oxidation of the sludge is induced by operating the latter activated sludge process at a low BOD sludge loading rate of 0.1 kg-BOD/kg-MLSS/d or less, which markedly reduce the amount of sludge drained.

[0008] The above-described multistage activated sludge process in which predation by animalcules is utilized has been in practical use for treating organic wastewater and is capable of increasing treatment efficiency and reducing the amount of sludge generated by about 50% depending on the type of wastewater targeted. However, the reduction in the amount of sludge is not achieved consistently. This is because a method for maintaining animalcules in a consistent manner has not yet been established and the ratio between the bacteria that serve as preys and animalcules has not yet been specified.

[0009] W02007/088860 describes a technique in which the amount of microorganisms present inside a microorganism-holding tank, which contribute to a reduction in the amount of sludge, is maintained to be consistent by reducing the soluble BOD sludge loading rate on a second biological treatment tank in which animalcules are held.

[0010] However, if the amount of dispersed bacteria present inside water treated in the first biological tank, which are to be charged into the second biological treatment

tank, is excessively large, animalcules present inside the second treatment tank may fail to completely prey upon the dispersed bacteria. In such a case, the amount of sludge generated is not reduced. In addition, since it is difficult to perform solid-liquid separation of dispersed bacteria, it is necessary to perform solid-liquid separation under mild condition regardless of the type of the solid-liquid separating means used. Moreover, the dispersed bacteria contained in the first biologically treated water are in a logarithmic growth phase. Therefore, if the dispersed bacteria are not preyed upon by animalcules but are auto-digested, the amount of soluble organic substance components may be increased, which makes it difficult to reuse water (recover wastewater).

List of Literature

Patent Literature

[0011] Patent Literature 1: Japanese Patent Publication 55-20649B

Patent Literature 2: Japanese Patent Publication 2000-210692A

Patent Literature 3: Japanese Patent Publication 60-23832B

Patent Literature 4: Japanese Patent 3410699

Patent Literature 5: W02007/088860

Object and Summary of Invention

Object of the Invention

[0012] An object of the present invention is to provide a method for biologically treating organic wastewater, the method including passing organic wastewater through an aerobic first biological treatment tank in order to generate dispersed bacteria by using bacteria and subsequently introducing first biologically treated water from the first biological treatment tank, which contains the dispersed bacteria, into an aerobic second biological treatment tank containing a fluidized-bed carrier so that animalcules prey upon the dispersed bacteria. In the method for biologically treating organic wastewater, a biological treatment can be performed in a consistent manner since the dispersed bacteria are adequately preyed upon in the second biological treatment tank.

Summary of the Invention

[0013] The present invention provides a method for biologically treating organic wastewater, the method comprising passing organic wastewater through an aerobic first biological treatment tank in order to generate dispersed bacteria by using bacteria and subsequently introducing first biologically treated water from the first biological treatment tank, the first biologically treated water containing the dispersed bacteria, into an aerobic second biological treatment tank containing a fluidized-bed

carrier so that animalcules prey upon the dispersed bacteria, wherein an overall BOD volumetric loading rate is $5 \text{ kg/m}^3/\text{d}$ or less, and wherein a rate at which a load of SS derived from the dispersed bacteria contained in the first biologically treated water is placed on the carrier contained in the second biological treatment tank (hereinafter, referred to as "dispersed bacteria-carrier loading rate") is $8 \text{ kg-SS/m}^3\text{-carrier/d}$ or less.

Advantageous Effects of the Invention

[0014] In the method according to the present invention, generation of dispersed bacteria in the first biological treatment tank and predation of the dispersed bacteria by animalcules in the second biological treatment tank occur in a balanced manner. This reduces the risk that the dispersed bacteria present inside the second biological treatment tank may fail to be completely removed (i.e., fail to be completely preyed upon).

Brief Description of Drawings

[0015] [Fig. 1] Fig. 1 is a flow diagram illustrating a method for biologically treating organic wastewater according to an embodiment.

[Fig. 2] Fig. 2 is a flow diagram illustrating a method for biologically treating organic wastewater according to an embodiment.

[Fig. 3] Fig. 3 is a flow diagram illustrating a method

for biologically treating organic wastewater according to an embodiment.

Description of Embodiment

[0016] The present invention is described more in detail below.

[0017] Fig. 1 illustrates a method for biologically treating organic wastewater according to an embodiment of the present invention. Organic wastewater is treated using a first biological treatment tank 1 and a second biological treatment tank 2. In this embodiment, aeration means 1b is disposed at the bottom of the first biological treatment tank 1, and the first biological treatment tank 1 serves as an aeration tank that does not contain a carrier. The second biological treatment tank 2 includes aeration means 2b disposed at the bottom thereof and serves as an aeration tank containing a carrier 2a.

[0018] Organic wastewater is introduced into the first biological treatment tank 1, and 70% or more, desirably 80% or more, and more desirably 85% to 90% of the amount of organic component (soluble BOD) of the organic wastewater is oxidatively decomposed by using bacteria. The pH of the first biological treatment tank 1 is 6 or more and is desirably 8 or less. The pH of the first biological treatment tank 1 may be 8.0 or more when the raw water contains a large amount of oil, an organic solvent, or a

surfactant. Setting the BOD volumetric loading rate on the first biological treatment tank 1 to $1 \text{ kg/m}^3/\text{d}$ or more, the HRT of the tank to 24 h or less, and the DO of the tank to 1 mg/L or less and desirably to 0.05 to 0.5 mg/L enables treated water in which dispersed bacteria are dominant to be produced. Reducing the HRT of the tank enables wastewater having a low BOD concentration to be treated at a high load.

[0019] Optionally, part of treated water from the latter biological treatment tank, which contains sludge, may be returned to the first biological treatment tank 1.

Alternatively, the first biological treatment tank 1 may be a multistage biological treatment tank. However, a retention time (HRT) larger than the optimum retention time may cause filamentous bacteria to gain dominance and formation of flock to occur, which results in generation of bacteria that are less likely to be preyed upon in the second biological treatment tank 2. Thus, the HRT of the first biological treatment tank 1 is preferably controlled to be constant. Since the optimum HRT varies depending on the type of wastewater, it is necessary to determine an HRT at which 70% to 90% of the amount of organic component can be removed on the basis of the results of a preliminary test, a simulation, or the like. Examples of a method for maintaining the HRT to be optimum include a method in which part of treated water is returned to the first biological

treatment tank 1 when the amount of wastewater is small in order to maintain the amount of water passed into the first biological treatment tank 1 to be constant, which enables the HRT of the first biological treatment tank 1 to be maintained constant; and a method in which the water level in the first biological treatment tank 1 is changed in accordance with fluctuations in the amount of wastewater. The HRT of the first biological treatment tank 1 is desirably maintained constant so as to be within a range of 0.75 to 1.5 times the optimum HRT determined from a preliminary test, a simulation, or the like.

[0020] Water treated in the first biological treatment tank 1 is introduced into the second biological treatment tank 2, which includes the aeration means 2b disposed at the bottom thereof. Oxidative decomposition of the remaining part of the organic component, autolysis of dispersed bacteria, and a reduction in the amount of excess sludge due to predation by animalcules are performed in the second biological treatment tank 2. Since the action of animalcules having a lower proliferation rate than bacteria and the autolysis of bacteria are utilized in the second biological treatment tank 2, it is preferable to employ operating conditions and a treatment apparatus that enable animalcules and bacteria to be retained inside the system. In order to increase the amount of animalcules retained

inside the tank, a carrier-separation screen 2c is disposed at a drainage portion of the second biological treatment tank 2. Furthermore, a fluidized-bed carrier 2a is used in order to form a fluidized bed.

[0021] The particles of the fluidized-bed carrier 2a may have any shape such as a spherical shape, a pellet-like shape, a hollow cylindrical shape, or a filamentous shape. The particles of the carrier 2a preferably have a diameter of about 0.1 to 10 mm. The carrier 2a may be composed of any material such as a natural material, an inorganic material, or a polymeric material. A gelatinous substance may also be used. The particles of the carrier 2a are desirably rectangular carrier particles composed of plastic foam. It is also possible to add, in addition to the fluidized-bed carrier, a filamentous carrier or a sheet-like carrier to the tank and fix portions of the particles of the filamentous carrier or sheet-like carrier to the inside of the tank in order to form an oscillating bed. This enables an overall carrier-filling proportion to be reduced.

[0022] In the present invention, the dispersed bacteria can be completely preyed upon by animalcules with certainty by setting an overall BOD volumetric loading rate to 5 kg/m³/d or less (the loading rate is set to be equal to or less than the predetermined loading rate even when the raw water is fluctuated) and controlling, for example, the DO of

the first biological treatment tank 1 and the carrier-filling proportion of the second biological treatment tank 2 such that a dispersed bacteria-carrier loading rate of 8 kg-SS/m³-carrier/d or less is achieved. In the case where the second biological treatment further contains the oscillating-bed carrier, the term "dispersed bacteria-carrier loading rate" refers to a rate at which a load of dispersed bacteria is placed on all the carrier particles including fluidized-bed carrier particles and the oscillating-bed carrier particles.

[0023] It is preferable to consider that fine SS particles contained in first biologically treated water which are capable of passing through an 8- μ m polycarbonate filter are SS particles derived from the dispersed bacteria.

[0024] SS particles contained in the first biologically treated water are classified into SS particles derived from dispersed bacteria contained in raw water, SS particles other than bacterial cells, and SS particles derived from dispersed bacteria generated in the first biological treatment tank 1. The size of SS particles derived from dispersed bacteria is less than 8 μ m in terms of the diameter of bacterial cells and is, for example, about 1 to 5 μ m. The diameter of SS particles other than bacterial cells which are less likely to be preyed upon by filter-predation animalcules is generally more than 8 μ m and is,

for example, about 10 to 50 μm . Thus, it is preferable to consider that SS particles capable of passing through a filter having a mesh size of 8 μm are SS particles derived from dispersed bacteria. The filter is preferably a perforated polycarbonate filter because, if a fibrous filter such as filter paper is used, fine SS particles may also be captured on the filter. The operating conditions of the second biological treatment tank 2, such as the amount of carrier added to the second biological treatment tank 2, are controlled on the basis of the results of measurement of the SS particles such that the load of the dispersed bacteria placed on the second biological treatment tank 2 does not exceed the limit.

[0025] As described above, a large part of organic substances, that is, specifically, 70% or more and desirably 80% or more of the amount of BOD contained in wastewater, is preferably decomposed and converted into bacterial cells in a consistent manner in the first biological treatment tank 1. Accordingly, it is desirable to dispose a carrier-separation screen 1c at a drainage portion of the first biological treatment tank 1 and add a carrier 1a to the first biological treatment tank 1 in order to form a fluidized bed as illustrated in Fig. 2. If the carrier-filling proportion of the first biological treatment tank 1 is excessively high, dispersed bacteria are not able to be generated. In such a

case, bacteria adhere to the carrier, or filamentous bacteria grow. Therefore, the proportion of the carrier charged into the first biological treatment tank 1 is preferably set to 20% or less and is particularly preferably 10% or less in order to generate dispersed bacteria that are likely to be preyed upon regardless of fluctuations in concentration. Carriers that can be used as the carrier 2a of the second biological treatment tank 2 may also be used as the carrier 1a of the first biological treatment tank 1.

[0026] A large amount of platforms are required in the second biological treatment tank 2 in order to maintain animalcules. Thus, in the case where a fluidized bed is formed, the proportion of carrier charged into the second biological treatment tank 2 is desirably set to 10% or more and is particularly desirably set to 20% or more, that is, for example, 20% to 40%.

[0027] The pH of the second biological treatment tank is preferably set to 7.0 or less, that is, for example, 6.0 to 7.0, in order to promote predation by animalcules.

[0028] In the case where soluble organic substances are almost completely decomposed in the first biological treatment tank 1 when the load is low at the initial stage of operation or due to fluctuations in raw water, a biofilm is less likely to be formed on the carrier particles in the second biological treatment tank. In addition, nourishment

used for proliferation of animalcules runs short. In such a case, it is desirable to divert and introduce part of the raw water into the second biological treatment tank 2 in order to perform an operation such that the soluble BOD sludge loading rate on the second biological treatment tank 2 is 0.001 kg-BOD/kg-MLSS/d or more and is desirably 0.025 to 0.1 kg-BOD/kg-MLSS/d.

[0029] Water treated in the second biological treatment tank 2 may be subjected to solid-liquid separation in order to produce treated water having high quality. Solid-liquid separating means may be one or more means selected from a sedimentation basin, flocculation sedimentation, flocculation pressure floatation separation, and membrane separation. Fig. 3 illustrates an example of the solid-liquid separating means. In a reaction tank 3, an inorganic flocculant is added to water treated in the second biological treatment tank 2. A polymeric flocculant is subsequently added to the treated water in a flocculation tank 4. Then, a sedimentation separation treatment is performed in a sedimentation tank 5 in order to separate settled sludge from the treated water.

Examples

[0030] [Example 1]

Raw water having a BOD of 800 mg/L and a COD_{cr} of 1300 mg/L (wastewater simulating wastewater from food factories)

was treated in accordance with the flow illustrated in Fig. 2. The volume of the first biological treatment tank 1 was 2.5 L. The volume of the second biological treatment tank 2 was 4.4 L. An operation was performed such that the DO of the first biological treatment tank 1 was 0.5 mg/L and the DO of the second biological treatment tank 2 was 2 to 3 mg/L. The first biological treatment tank 1 was filled with a carrier at a carrier-filling proportion of 5%. The second biological treatment tank 2 was filled with a carrier at a carrier-filling proportion of 40%. The carrier particles charged in these tanks were rectangular sponge carrier particles made of polyurethane which had a diameter of 3 mm.

[0031] An operation was performed such that the BOD volumetric loading rate on the first biological treatment tank 1 was 5.5 kg-BOD/m³/d, the HRT of the first biological treatment tank 1 was 3.5 h, the overall BOD volumetric loading rate was 2.0 kg-BOD/m³/d, and the total HRT was 9.6 h. The SS concentration in the first biologically treated water was 600 mg/L. The dispersed bacteria-carrier loading rate was 5.9 kg-SS/m³-carrier/d. As a result, the SS concentration in the second biologically treated water was 250 mg/L. A sludge conversion ratio of 0.19 kg-SS/kg-COD_{Cr} was achieved.

[0032] [Example 2]

The raw water was treated under the same conditions as

in Example 1, except that the treatment was performed in accordance with the flow illustrated in Fig. 3 by disposing a reaction tank 3, a flocculation tank 4, and a sedimentation tank 5 downstream of the second biological treatment tank 2. PAC was used as an inorganic flocculant at a concentration of 300 mg/L. KURIFLOCK PA331 produced by Kurita Water Industries Ltd was used as an anionic polymeric flocculant at a concentration of 1 mg/L. As a result, a sludge conversion ratio of 0.19 kg-SS/kg-COD_{cr} (excluding PAC sludge) was achieved. The COD_{cr} of the treated water and the SS concentration in the treated water were 20 mg/L or less. That is, the quality of the treated water was maintained high.

[0033] [Comparative Example 1]

An operation was performed under the same conditions as in Example 1, except that the carrier-filling proportion of the second biological treatment tank 2 was changed to 25% and the dispersed bacteria-carrier loading rate on the carrier 2a of the second biological treatment tank 2 was changed to 9.4 kg-SS/m³-carrier/d. As a result, a part of dispersed bacteria which was not able to be preyed upon was discharged, which resulted in a sludge conversion ratio of 0.29 kg-SS/kg-COD_{cr}.

[0034] [Comparative Example 2]

An operation was performed under the same conditions as

in Example 2, except that the carrier-filling proportion of the second biological treatment tank 2 was changed to 25% and the dispersed bacteria-carrier loading rate on the carrier 2a of the second biological treatment tank 2 was changed to 9 kg-SS/m³-carrier/d. As a result, a part of dispersed bacteria which was not able to be preyed upon was discharged, which resulted in a sludge conversion ratio of 0.29 kg-SS/kg-COD_{cr} (excluding PAC sludge). In order to reduce the SS concentration in the treated water to 20 mg/L or less by performing flocculation, the concentration of PAC used was increased to 800 mg/L and the concentration of the anionic polymer used was increased to 2 mg/L. Despite the above conditions, the COD_{cr} of the treated water was 30 mg/L, that is, the quality of treated water was degraded compared with that of Example 2.

[0035] Although the present invention has been described in detail with reference to a particular embodiment, it is apparent to a person skilled in the art that various modifications can be made therein without departing from the spirit and scope of the present invention.

The present application is based on Japanese Patent Application No. 2012-080521 filed on March 30, 2012, which is incorporated herein by reference in its entirety.

CLAIMS

[Claim 1]

A method for biologically treating organic wastewater, the method comprising passing organic wastewater through an aerobic first biological treatment tank in order to generate dispersed bacteria by using bacteria and subsequently introducing first biologically treated water from the first biological treatment tank, the first biologically treated water containing the dispersed bacteria, into an aerobic second biological treatment tank containing a fluidized-bed carrier so that animalcules prey upon the dispersed bacteria,

wherein an overall BOD volumetric loading rate is 5 kg/m³/d or less, and

wherein a rate at which a load of SS derived from the dispersed bacteria contained in the first biologically treated water is placed on the carrier contained in the second biological treatment tank (hereinafter, referred to as "dispersed bacteria-carrier loading rate") is 8 kg-SS/m³-carrier/d or less.

[Claim 2]

The method for biologically treating organic wastewater according to Claim 1, wherein the first biological treatment tank is a fluidized-bed biological treatment tank having a carrier-filling proportion of 20% or less and the second biological treatment tank is a fluidized-bed biological

treatment tank having a carrier-filling proportion of 10% or more.

[Claim 3]

The method for biologically treating organic wastewater according to Claim 1 or 2, wherein water treated in the second biological treatment tank is subjected to solid-liquid separation by using solid-liquid separating means to be separated into sludge and treated water, the solid-liquid separating means being at least one selected from flocculation sedimentation, flocculation pressure floatation separation, and membrane separation.

[Claim 4]

The method for biologically treating organic wastewater according to any one of Claims 1 to 3, wherein the second biological treatment tank has a pH of 6 to 7.

[Claim 5]

The method for biologically treating organic wastewater according to any one of Claims 1 to 4, wherein part of raw water is added to the second biological treatment tank.

[Claim 6]

The method for biologically treating organic wastewater according to any one of Claims 1 to 5, wherein a part of SS particles contained in the first biologically treated water, the part of SS particles being derived from the dispersed bacteria, are fine SS particles capable of passing through

an 8- μm polycarbonate filter.