

DESCRIPTION

SEWAGE TREATMENT DEVICE AND SEWAGE TREATMENT METHOD

TECHNICAL FIELD

5 [0001] The present disclosure relates to a sewage treatment device and a sewage treatment method.

BACKGROUND ART

[0002] In a sewage treatment plant, flow-in sewage is
10 treated and the treated water is released to a river or the ocean. In order to release the treated water, inorganic or organic suspended substances and soluble organic substances contained in the sewage need to be removed to a reference level. Therefore, in the sewage treatment plant, the
15 suspended substances are removed through filtration and settlement, and the organic substances are removed by being decomposed through a biological treatment. As the biological treatment for the organic substances, a method called an activated sludge process is used. In the activated sludge
20 process, sewage is caused to flow into an aeration tank containing a large amount of microorganisms, while being aerated with air, whereby organic substances are decomposed by the microorganisms. After the organic substances are decomposed, water and the microorganisms are separated
25 through settlement in a settling tank, thus obtaining treated

water with the organic substance concentration reduced to the reference level.

[0003] The microorganisms used in the activated sludge process grow by obtaining energy while decomposing organic substances in sewage. When the microorganism concentration in the aeration tank increases, it becomes difficult to separate the microorganisms and the treated water by settlement. In order to prevent this, in the settling tank, the sludge in which the microorganisms have grown is extracted as excess sludge. The excess sludge is unnecessary sludge in the sewage treatment. Therefore, the excess sludge is disposed of as industrial waste through a process such as incineration, drying, or landfill. Such disposal of excess sludge requires enormous energy, cost, new sites, and the like.

[0004] The amount of excess sludge generated in the sewage treatment plant is 1 to 5% of sewage. For reducing the disposal cost therefor, various volume reduction treatments to reduce the amount of excess sludge are performed. The most general volume reduction treatment is dewatering. If approximately 95% of water contained in the excess sludge is removed, the volume of excess sludge is reduced to approximately 1/2500. Further, for reducing the volume of excess sludge, a method of modifying the excess sludge to be put into an aeration tank or an anaerobic digestion tank is

used. Ozone gas is used for efficiently modifying a large amount of excess sludge. Disclosed is a method in which ozone gas is injected into excess sludge by using an ejector and the excess sludge with ozone injected therein is stored
5 in a reaction tank to modify the excess sludge (see, for example, Patent Document 1).

CITATION LIST

PATENT DOCUMENT

- 10 [0005] Patent Document 1: Japanese Laid-Open Patent
Publication No. 2-222798

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

- 15 [0006] In Patent Document 1, excess sludge is directly injected into the ejector so that ozone gas comes into contact with the excess sludge. Therefore, it is possible to modify the excess sludge without complicating equipment. In order to efficiently bring ozone gas and excess sludge into
20 contact with each other and modify the excess sludge, it is necessary to generate fine ozone gas bubbles inside the ejector. For this purpose, the flow speed of excess sludge passing through a narrow portion of the ejector needs to be increased to tear the bubbles by a shear force. However, in
25 a case where excess sludge containing flocs of organic

substances with a size of several millimeters and having a high sludge concentration is directly injected into the ejector, the viscosity of the excess sludge increases due to the flocs, and the excess sludge is subjected to resistance when flowing through the ejector narrow portion. Thus, the flow speed of the sludge decreases at the narrow portion, resulting in a problem that bubbles of injected ozone gas are not made into a fine size. In order to increase the flow speed of the excess sludge at the ejector narrow portion and generate fine ozone gas bubbles, it is necessary to increase the pressure of a pump for injecting the excess sludge into the ejector. However, if the pump pressure is increased, motive power for ozone treatment is increased, thus causing a problem of increasing the load of ozone treatment.

[0007] The present disclosure has been made to solve the above problems, and an object of the present disclosure is to obtain a sewage treatment device that allows fine ozone gas bubbles to be generated in an ejector without increasing the load of ozone treatment.

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SOLUTION TO THE PROBLEMS

[0008] A sewage treatment device according to the present disclosure is a sewage treatment device including: a water treatment device which performs treatment on sewage to obtain treated water; a dewatering treatment device which performs

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volume reduction treatment of reducing an amount of excess
sludge generated in the treatment; and a sludge treatment
device which reduces an amount of the excess sludge generated
in the treatment and/or an amount of concentrated excess
5 sludge generated in the volume reduction treatment. The
sludge treatment device includes: an excess sludge tank which
stores the excess sludge and/or the concentrated excess
sludge as stored sludge; an ozone gas generator which
generates ozone gas; a mixing unit which mixes a low-
10 viscosity solution and the stored sludge supplied from the
excess sludge tank, to generate mixed sludge; an ejector
which generates ozone-treated sludge by injecting the ozone
gas into the mixed sludge flowing out from the mixing unit;
and an ozone-treated sludge tank which stores the ozone-
15 treated sludge flowing out from the ejector. The low-
viscosity solution is a solution having a lower viscosity
than the stored sludge.

EFFECT OF THE INVENTION

20 [0009] The sewage treatment device according to the
present disclosure can generate fine ozone gas bubbles in an
ejector without increasing the load of ozone treatment.

BRIEF DESCRIPTION OF THE DRAWINGS

25 [0010] [FIG. 1] FIG. 1 is a schematic view showing an

overall structure of a sludge treatment device which is a part of a sewage treatment device according to embodiment 1.

[FIG. 2] FIG. 2 is a schematic view showing an overall structure of the sewage treatment device according to
5 embodiment 1.

[FIG. 3] FIG. 3 is a chart showing a process for modifying excess sludge by the sludge treatment device which is a part of the sewage treatment device according to embodiment 1.

10 [FIG. 4] FIG. 4 is a schematic view showing another overall structure of the sludge treatment device which is a part of the sewage treatment device according to embodiment 1.

[FIG. 5] FIG. 5 is a schematic view showing an
15 overall structure of a sludge treatment device which is a part of a sewage treatment device according to embodiment 2.

[FIG. 6] FIG. 6 is a graph showing the relationship between an ozone gas injection time and the viscosity of excess sludge.

20 [FIG. 7] FIG. 7 is a schematic view showing an overall structure of a sludge treatment device which is a part of a sewage treatment device according to embodiment 3.

[FIG. 8] FIG. 8 is a schematic view showing another overall structure of the sludge treatment device
25 which is a part of the sewage treatment device according to

embodiment 3.

[FIG. 9] FIG. 9 is a schematic view showing an overall structure of a sewage treatment device according to embodiment 4.

5 [FIG. 10] FIG. 10 is a schematic view showing another overall structure of the sewage treatment device according to embodiment 4.

[FIG. 11] FIG. 11 is a schematic view showing still another overall structure of the sewage treatment
10 device according to embodiment 4.

[FIG. 12] FIG. 12 is a schematic view showing an overall structure of a sewage treatment device according to embodiment 5.

[FIG. 13] FIG. 13 is a schematic view showing an
15 overall structure of a sludge treatment device which is a part of a sewage treatment device according to embodiment 6.

DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, a sewage treatment device and a sewage
20 treatment method according to embodiments of the present disclosure will be described with reference to the drawings. In the drawings, the same or corresponding members or parts are denoted by the same reference characters, to give description.

25 [0012] Embodiment 1

FIG. 1 is a schematic view showing an overall structure of a sludge treatment device which is a part of a sewage treatment device according to embodiment 1, and FIG. 2 is a schematic view showing an overall structure of the sewage treatment device. A sewage treatment device 300 includes a water treatment device 301 which performs treatment on sewage 105 through an activated sludge process to obtain treated water 106, a dewatering treatment device 302 which performs volume reduction treatment for reducing the amount of excess sludge 100 generated in the treatment, and a sludge treatment device 200 which reduces the amount of the excess sludge 100 generated in the treatment and/or the amount of concentrated excess sludge 110 generated in the volume reduction treatment. Volume-reduced sludge 109 is disposed of as industrial waste through a process such as incineration, drying, or landfill.

[0013] The sludge treatment device 200 is a device which, in order to reduce the volume of the excess sludge 100 and/or the concentrated excess sludge 110 stored as stored sludge in the excess sludge tank 1, modifies the stored sludge by using ozone gas 104. The modification refers to dissolving organic substances contained in the excess sludge, making the sludge particle size into a fine size, and the like. The sludge treatment device 200 includes the excess sludge tank 1, a mixing tank 3 which is a mixing unit, a low-viscosity

solution tank 5, an ejector 9, an ozone gas generator 12 for generating ozone gas 104, and an ozone-treated sludge tank 13.

[0014] The excess sludge tank 1 and the mixing tank 3 are
5 connected via an excess sludge supply pipe 2, and an excess
sludge supply pump 4 for supplying the stored sludge to the
mixing tank 3 is provided to the excess sludge supply pipe 2.
The low-viscosity solution tank 5 storing a low-viscosity
solution 101 having a lower viscosity than the stored sludge,
10 and the mixing tank 3, are connected via a low-viscosity
solution supply pipe 6, and a low-viscosity solution supply
pump 7 for supplying the low-viscosity solution 101 to the
mixing tank 3 is provided to the low-viscosity solution
supply pipe 6. The mixing tank 3 for generating mixed sludge
15 102 by mixing the supplied stored sludge and the low-
viscosity solution 101 with a stirrer (not shown), a
circulation pump (not shown), or the like, and the ejector 9,
are connected via a mixed sludge supply pipe 8, and a mixed
sludge supply pump 10 for causing the mixed sludge 102 to
20 flow into the ejector 9 is provided to the mixed sludge
supply pipe 8. The ejector 9 and the ozone gas generator 12
are connected via an ozone supply pipe 11. The ejector 9 for
generating ozone-treated sludge 103 by injecting the ozone
gas 104 into the flow-in mixed sludge 102, and the ozone-
25 treated sludge tank 13, are connected via an ozone-treated

sludge flow-in pipe 14. An ozone-treated sludge flow-out pipe 15 for discharging the ozone-treated sludge 103 is connected to the ozone-treated sludge tank 13 which stores the flow-in ozone-treated sludge 103.

5 [0015] Here, a process in which the sludge treatment device 200 modifies the excess sludge 100 and/or the concentrated excess sludge 110 by using the ozone gas 104 so as to reduce the volume thereof, will be described. FIG. 3 is a chart showing the process for modifying the excess
10 sludge by the sludge treatment device 200 which is a part of the sewage treatment device 300 according to embodiment 1. The excess sludge supply pump 4 is operated to supply the stored sludge formed from the excess sludge 100 and/or the concentrated excess sludge 110 generated in the sewage
15 treatment, to the mixing tank 3. In addition, the low-viscosity solution supply pump 7 is operated to supply the low-viscosity solution 101 to the mixing tank 3. In the mixing tank 3, the stored sludge and the low-viscosity solution 101 are efficiently mixed to generate the mixed
20 sludge 102 (step S11). The mixed sludge supply pump 10 is operated to cause the mixed sludge 102 to flow into the ejector 9, and the ozone gas 104 is injected into the ejector 9 through the ozone supply pipe 11. In the ejector 9, ozone gas bubbles generated from the ozone gas 104 are injected
25 into the mixed sludge 102 (step S12). The excess sludge

contained in the mixed sludge 102 is modified with the ozone gas bubbles, to generate the ozone-treated sludge 103 (step S13). The ozone-treated sludge 103 flows into the ozone-treated sludge tank 13 through the ozone-treated sludge flow-
5 in pipe 14. In the ozone-treated sludge tank 13, modification of the excess sludge further progresses through reaction between the ozone gas bubbles and the excess sludge. The ozone-treated sludge 103 is extracted to the outside through the ozone-treated sludge flow-out pipe 15 so that the
10 liquid amount in the ozone-treated sludge tank 13 is kept constant (step S14). The outside is an aeration tank 31 provided in the water treatment device 301 or an anaerobic digestion tank 34 provided in the dewatering treatment device 302, and the ozone-treated sludge 103 is further reduced in
15 volume.

[0016] The process in the ejector 9 will be described. The mixed sludge 102 that has flowed into the ejector 9 is pressurized before passing through a narrow portion 9a of the ejector 9, and is depressurized after passing through the
20 narrow portion 9a. The ozone gas 104 is injected into the narrow portion 9a. Through pressurization and depressurization of the mixed sludge 102 caused before and after the narrow portion of the ejector 9 while the mixed sludge 102 flows, the ozone gas bubbles injected into the
25 mixed sludge 102 are subjected to a shear force. With the

shear force, the ozone gas bubbles are torn, whereby fine ozone gas bubbles are generated. The diameter of the generated ozone gas bubbles is relevant to the shear force and the flow rate of the ozone gas 104 injected into the ejector 9. The diameter of the ozone gas bubbles becomes smaller as the flow rate of the ozone gas 104 injected into the ejector 9 is reduced, and the diameter of the ozone gas bubbles becomes smaller as the shear force increases. The shear force in the narrow portion of the ejector 9 increases as the flow speed of the mixed sludge 102 flowing through the narrow portion 9a increases. The flow speed of the mixed sludge 102 flowing through the narrow portion 9a is determined by the flow rate of the mixed sludge 102 and the sectional area of the narrow portion 9a. That is, the diameter of the ozone gas bubbles is determined by the flow rate of the ozone gas 104 injected into the ejector 9, the flow rate of the mixed sludge 102, and the sectional area of the narrow portion 9a, and therefore, in a case of using the ejector 9 having a constant sectional area, it is possible to control the diameter of the ozone gas bubbles by controlling the flow rate of the ozone gas 104 and the flow rate of the mixed sludge 102.

[0017] In the ejector 9, in order to efficiently react the ozone gas 104 and the mixed sludge 102 to generate the ozone-treated sludge 103, fine ozone gas bubbles having a diameter

of 1 micrometer to 1 millimeter need to be generated inside the ejector 9. For this purpose, the flow rate of the mixed sludge 102 needs to be equal to or greater than ten times the flow rate of the ozone gas 104 injected into the ejector 9.

5 If the excess sludge is used as it is, the viscosity thereof is high and therefore the resistance at the time of passing through the ejector 9 is great. Thus, a desired flow rate is not readily obtained and fine bubbles of ozone gas cannot be generated. If the sludge is injected into the ejector 9 as
10 it is in the excess sludge state, the pressure for pressurization by the mixed sludge supply pump 10 increases with increase in the concentration of the excess sludge, so that the load of ozone treatment increases. Therefore, the stored sludge and the low-viscosity solution 101 are mixed in
15 the mixing tank 3, to generate the mixed sludge 102 having a lower viscosity than the stored sludge. Since the low-viscosity solution 101 has a lower viscosity than the stored sludge, the viscosity of the mixed sludge 102 becomes lower than the viscosity of the stored sludge. The viscosity of
20 the mixed sludge 102 changes in accordance with a mixed liquid amount ratio between the stored sludge and the low-viscosity solution 101. As the mixed amount of the low-viscosity solution 101 increases, the viscosity of the mixed sludge 102 comes close to the viscosity of the low-viscosity
25 solution 101. The pressure required for the mixed sludge 102

to flow through the narrow portion 9a at such a flow speed as to generate fine ozone gas bubbles is lower than that required for the excess sludge 100. Therefore, without increasing the load of ozone treatment for increasing the pressure of pressurization by the mixed sludge supply pump, the excess sludge 100 and the ozone gas can be efficiently reacted with each other.

[0018] As the low-viscosity solution 101, a solution having a lower viscosity than the stored sludge may be used.

10 As the low-viscosity solution 101, for example, the treated water 106 after sewage treatment can be used, and sludge may be contained as long as the viscosity is low. In addition, a chemical such as an acid or an alkali may be used for the low-viscosity solution 101. For example, the chemical is
15 sulfuric acid solution or sodium hydroxide solution.

[0019] Next, the excess sludge 100 and the concentrated excess sludge 110 which are extracted into the excess sludge tank 1 will be described. In FIG. 2, the water treatment device 301 includes the aeration tank 31 for treating the
20 flow-in sewage 105 into the excess sludge 100 through the activated sludge process, and a settling tank 32 for separating the treated water 106 from the excess sludge 100 extracted from the aeration tank 31. The dewatering treatment device 302 includes a concentrating machine 33 for
25 concentrating the excess sludge 100 extracted from the

settling tank 32 to generate the concentrated excess sludge 110, the anaerobic digestion tank 34 for treating the concentrated excess sludge 110 with digestion sludge 108, and a dewatering machine 35 for dewatering the sludge treated in the anaerobic digestion tank 34, to reduce the volume thereof.

[0020] The details of the water treatment device 301 and the dewatering treatment device 302 will be described. Microorganisms which decompose organic substances and are called activated sludge are stored in the aeration tank 31. The microorganisms decompose organic substances contained in sewage using oxygen in the air of aeration in the aeration tank 31, and grow using energy obtained by decomposing the organic substances. The microorganisms that have grown to have an increased concentration correspond to the excess sludge 100. The excess sludge 100 containing the treated water in which the organic substances have been removed is extracted into the settling tank 32. In the settling tank 32, the microorganisms are settled to be separated from the treated water 106. Some of the microorganisms are returned as return sludge 107 to the aeration tank 31, and the other microorganisms are extracted as the excess sludge 100 into the dewatering treatment device 302. The treated water 106 flows out from the settling tank 32, and is released to a river or the ocean after subjected to sterilization and the

like.

[0021] The excess sludge 100 extracted from the settling tank 32 into the dewatering treatment device 302 is treated through the concentrating machine 33 and the anaerobic digestion tank 34, and then is reduced in volume through dewatering by the dewatering machine 35, to be discarded. If the excess sludge 100 is directly put into the dewatering machine 35, a large amount of waste is generated because the excess sludge 100 contains a large amount of solid materials. Therefore, the generation amount of waste is reduced through treatments in the concentrating machine 33 and the anaerobic digestion tank 34. The concentrating machine 33 separates water from the excess sludge 100 to reduce the volume thereof to 1/3 to 1/10, thereby generating the concentrated excess sludge 110. Owing to reduction in the volume of the excess sludge 100, the size of the anaerobic digestion tank 34 at the subsequent stage can be reduced to 1/3 to 1/10 in accordance with the volume of the concentrated excess sludge 110. The concentrated excess sludge 110 is put into the anaerobic digestion tank 34. In the anaerobic digestion tank 34, microorganisms which are called digestion sludge 108 and decompose the microorganisms in the concentrated excess sludge 110, are stored. Over a period of about 20 to 40 days, 50 to 60% of solid materials contained in the concentrated excess sludge 110 are dissolved by the

microorganisms of the digestion sludge 108, whereby the concentrated excess sludge 110 is decomposed into carbon dioxide and methane gas. The remaining sludge is put into the dewatering machine 35 and dewatered to be volume-reduced sludge 109, which is then discarded.

[0022] The excess sludge tank 1 and the aeration tank 31 are connected via a first excess sludge storage pipe 36, and the excess sludge 100 in the aeration tank 31 is extracted and stored into the excess sludge tank 1. The excess sludge tank 1 and the settling tank 32 are connected via a second excess sludge storage pipe 37, and the excess sludge 100 in the settling tank 32 is extracted and stored into the excess sludge tank 1. The excess sludge tank 1 and the concentrating machine 33 are connected via a third excess sludge storage pipe 38, and the concentrated excess sludge 110 is extracted from a stage subsequent to the concentrating machine 33 and is stored into the excess sludge tank 1. The amount of the excess sludge 100 to be extracted and the amount of the concentrated excess sludge 110 to be extracted may be optionally determined. The concentration of the excess sludge extracted through each of the first excess sludge storage pipe 36, the second excess sludge storage pipe 37, and the third excess sludge storage pipe 38 is different from each other. The concentration of the excess sludge 100 extracted from the aeration tank 31 is 0.5 g/L to 2 g/L, the

concentration of the excess sludge 100 extracted from the settling tank 32 is 4 g/L to 8 g/L, and the concentration of the concentrated excess sludge 110 is 30 g/L to 50 g/L. Each excess sludge has flocs formed by flocculation of the microorganisms used in the activated sludge, and thus has a higher viscosity than water. The sewage treatment device 300 has a configuration having all of the first excess sludge storage pipe 36, the second excess sludge storage pipe 37, and the third excess sludge storage pipe 38, but without limitation thereto, the sewage treatment device 300 may have a configuration having any two of the above pipes or any one of the above pipes. For this reason, these pipes are indicated by dotted lines in FIG. 2.

[0023] In the above description, the configuration in which the low-viscosity solution 101 is supplied to the mixing tank 3 from the low-viscosity solution tank 5 storing the low-viscosity solution 101, has been shown, but another configuration may be adopted. For example, as shown in FIG. 4, the mixing tank 3 and the settling tank 32 may be connected via a pipe and thus the treated water 106 as the low-viscosity solution 101 may be supplied from the settling tank 32 to the mixing tank 3. In this configuration, the low-viscosity solution tank 5 is not needed, and therefore a sludge treatment device 201 can be formed in a small size.

[0024] As described above, in the sludge treatment device

200 which is a part of the sewage treatment device 300 according to embodiment 1, the stored sludge and the low-viscosity solution 101 are mixed to generate the mixed sludge 102 having a lower viscosity than the stored sludge, and the mixed sludge 102 is injected into the ejector 9. Therefore, without increasing the load of ozone treatment for increasing the pressure of pressurization by the mixed sludge supply pump 10, fine ozone gas bubbles are generated inside the ejector 9, whereby the excess sludge and the ozone gas 104 can be efficiently reacted with each other. In addition, the low-viscosity solution 101 is supplied to the mixing tank 3 from the low-viscosity solution tank 5 storing the low-viscosity solution 101. Therefore, by preparing the low-viscosity solution 101 in the low-viscosity solution tank 5, it is possible to smoothly start operation of the sludge treatment device 200. In addition, the mixed sludge 102 is generated in the mixing tank 3. Therefore, by providing a stirrer, a circulation pump, or the like to the mixing tank, the excess sludge and the low-viscosity solution 101 can be efficiently mixed. In addition, the excess sludge and the low-viscosity solution 101 are mixed to generate the mixed sludge 102 having a low viscosity. Therefore, even if excess sludge having a different concentration is stored in the excess sludge tank 1, it is possible to efficiently perform volume reduction treatment.

[0025] Embodiment 2

A sludge treatment device 202 according to embodiment 2 will be described. FIG. 5 is a schematic view showing an overall structure of the sludge treatment device which is a part of a sewage treatment device according to embodiment 2. The sludge treatment device 202 according to embodiment 2 is configured to use the ozone-treated sludge 103 as the low-viscosity solution 101, without having the low-viscosity solution tank 5 provided to the sludge treatment device 200 in embodiment 1.

[0026] The ozone-treated sludge tank 13 and the mixing tank 3 are connected via an ozone-treated sludge circulation pipe 16, and an ozone-treated sludge circulation pump 17 for supplying the ozone-treated sludge 103 from the ozone-treated sludge tank 13 to the mixing tank 3 is provided to the ozone-treated sludge circulation pipe 16. The ozone-treated sludge circulation pump 17 is operated so that the ozone-treated sludge 103 is supplied from the ozone-treated sludge tank 13 to the mixing tank 3 through the ozone-treated sludge circulation pipe 16. In the mixing tank 3, the stored sludge and the ozone-treated sludge 103 are efficiently mixed to generate the mixed sludge 102. In a case where the mixing tank 3 has an airtight structure, the pressure by the ozone-treated sludge circulation pump 17 is applied also to the mixed sludge 102 in the mixing tank 3. With this pressure,

the mixed sludge 102 is pushed out from the mixing tank 3, to flow through the mixed sludge supply pipe 8 into the ejector 9. In the case where the mixing tank 3 has an airtight structure, the mixed sludge supply pump 10 provided to the sludge treatment device 200 in embodiment 1 need not be provided.

[0027] The fact that the ozone-treated sludge 103 can be used as a low-viscosity solution will be described. When the ozone gas 104 is injected into the excess sludge and thus the sludge is modified, the viscosity of the excess sludge sharply decreases. FIG. 6 is a graph showing the relationship between an ozone gas injection time for excess sludge having a concentration of 35 g/L, and the viscosity of the excess sludge. The viscosity of the excess sludge decreases with increase in the ozone gas injection time. In FIG. 6, the viscosity, which is 4 Pa·s before the injection, decreases to 0.5 Pa·s 140 minutes later. The viscosity of the ozone-treated sludge 103 modified as described above is lower than the viscosity of the excess sludge, and therefore the ozone-treated sludge 103 can be used as a low-viscosity solution.

[0028] The configuration shown in FIG. 5 is not a configuration in which the low-viscosity solution 101 is newly added from the low-viscosity solution tank 5 as in the sludge treatment device 200 of embodiment 1 shown in FIG. 1.

Therefore, the original sludge that had been contained in the excess sludge is present in the ozone-treated sludge 103.

Thus, the liquid amount of the ozone-treated sludge 103 supplied from the ozone-treated sludge tank 13 to the mixing tank 3 is equal to the liquid amount of the excess sludge that initially flowed in from the excess sludge tank 1.

Since the liquid amount of the excess sludge and the liquid amount of the ozone-treated sludge 103 are equal to each other, the present configuration can suppress size increase in the sludge treatment device.

[0029] As described above, the sludge treatment device 202 according to embodiment 2 is configured such that the ozone-treated sludge 103 having a viscosity reduced through modification is supplied as a low-viscosity solution to the mixing tank 3. Therefore, the liquid amount of the ozone-treated sludge 103 is equal to the liquid amount of the excess sludge that initially flowed in from the excess sludge tank 1, whereby size increase in the sludge treatment device can be suppressed.

[0030] Embodiment 3

A sludge treatment device 203 according to embodiment 3 will be described. FIG. 7 is a schematic view showing an overall structure of the sludge treatment device which is a part of a sewage treatment device according to embodiment 3. The sludge treatment device 203 according to

embodiment 3 is configured to have a mixer 18 as a mixing unit, instead of the mixing tank 3 provided to the sludge treatment device 202 in embodiment 2.

[0031] The excess sludge tank 1 and the mixer 18 are
5 connected via the excess sludge supply pipe 2, and the excess
sludge supply pump 4 for supplying the stored sludge to the
mixer 18 is provided to the excess sludge supply pipe 2. The
excess sludge supply pump 4 is operated so that the stored
sludge is supplied from the excess sludge tank 1 to the mixer
10 18 through the excess sludge supply pipe 2. The ozone-
treated sludge tank 13 and the mixer 18 are connected via the
ozone-treated sludge circulation pipe 16, and the ozone-
treated sludge circulation pump 17 for supplying the ozone-
treated sludge 103 from the ozone-treated sludge tank 13 to
15 the mixer 18 is provided to the ozone-treated sludge
circulation pipe 16. The ozone-treated sludge circulation
pump 17 is operated so that the ozone-treated sludge 103 is
supplied from the ozone-treated sludge tank 13 to the mixer
18 through the ozone-treated sludge circulation pipe 16. In
20 the mixer 18, the stored sludge and the ozone-treated sludge
103 are efficiently mixed to generate the mixed sludge 102.

[0032] The mixer 18 may be, for example, a static mixer or
a turbo mixer using a mechanical mechanism. The mixer 18 has
a small size as compared to the mixing tank, and is provided
25 as a part of the pipe in the sludge treatment device 203.

Therefore, with the configuration shown in embodiment 3, the sludge treatment device 203 can be formed in a small size.

[0033] In the above description, the configuration in which the excess sludge 100 and the ozone-treated sludge 103 are mixed using the mixer 18, has been shown. However, without limitation thereto, as shown in FIG. 8, the excess sludge supply pipe 2 and the ozone-treated sludge circulation pipe 16 may be connected without providing the mixer 18, and a connection portion 19 therebetween may be used as a mixing unit. The excess sludge and the ozone-treated sludge 103 are mixed inside the connected pipes. In this configuration, the mixer 18 is not needed and therefore the sludge treatment device 204 can be formed in a smaller size although the flow rate of the sludge is restricted.

[0034] As described above, the sludge treatment device 203 according to embodiment 3 is configured such that the excess sludge and the ozone-treated sludge 103 are mixed by the mixer 18. Thus, the sludge treatment device 203 can be formed in a small size.

[0035] Embodiment 4

A sludge treatment device according to embodiment 4 will be described. FIG. 9 is a schematic view showing an overall structure of a sewage treatment device according to embodiment 4, and FIG. 10 is a schematic view showing another overall structure of the sewage treatment device according to

embodiment 4. In embodiment 4, the ozone-treated sludge 103 is put into the aeration tank 31 or the anaerobic digestion tank 34 from the ozone-treated sludge flow-out pipe 15 of the sludge treatment device 202 shown in embodiment 2.

5 [0036] As shown in FIG. 9, a pipe on the upstream side of the aeration tank 31 at which the sewage 105 flows in, and the ozone-treated sludge tank 13, are connected via the ozone-treated sludge flow-out pipe 15 for putting the ozone-treated sludge 103 into the aeration tank 31. The excess
10 sludge 100 extracted from the aeration tank 31 or the settling tank 32 is modified by the ozone gas 104, to be the ozone-treated sludge 103. The ozone-treated sludge 103 is returned through the ozone-treated sludge flow-out pipe 15 to the upstream side of the aeration tank 31, and then is put
15 into the aeration tank 31. Even if the ozone-treated sludge 103 is returned to the aeration tank 31, the ozone-treated sludge 103 corresponds to, before the treatment, the excess sludge 100 extracted from the aeration tank 31 or the settling tank 32, and therefore the sewage treatment amount
20 itself does not change. The ozone-treated sludge 103 put into the aeration tank 31 is decomposed by the activated sludge, and therefore the amount of the excess sludge 100 to be discarded is reduced.

[0037] A configuration shown in FIG. 10 may be adopted.
25 In the configuration shown in FIG. 10, the pipe on the

upstream side of the anaerobic digestion tank 34 at which the concentrated excess sludge flows in, and the ozone-treated sludge tank 13, are connected via the ozone-treated sludge flow-out pipe 15 for putting the ozone-treated sludge 103 into the anaerobic digestion tank 34. The concentrated excess sludge 110 is modified by the ozone gas 104, to be the ozone-treated sludge 103. The ozone-treated sludge 103 is returned through the ozone-treated sludge flow-out pipe 15 to the upstream side of the anaerobic digestion tank 34, and then is put into the anaerobic digestion tank 34. Even if the concentrated excess sludge 110 is modified, the liquid amounts of the original excess sludge 100 and the ozone-treated sludge 103 do not change. Therefore, the ozone-treated sludge 103 can be subjected to the anaerobic digestion treatment in the same manner as the concentrated excess sludge 110. In the ozone-treated sludge 103, organic substances have been dissolved and the sludge particle size has been made into a fine size, as compared to the concentrated excess sludge 110. Thus, the volume reduction effect due to anaerobic digestion is improved.

[0038] In FIG. 10, the concentrated excess sludge 110 generated in the concentrating machine 33 is divisionally put into the excess sludge tank 1 and the anaerobic digestion tank 34. The amounts of the concentrated excess sludge 110 divisionally put into the excess sludge tank 1 and the

anaerobic digestion tank can be optionally set. As shown in FIG. 11, the entire amount of the concentrated excess sludge 110 may be put into the excess sludge tank 1, to be subjected to the ozone treatment.

5 [0039] As described above, the sewage treatment device according to embodiment 4 is configured such that the ozone-treated sludge 103 is put into the aeration tank 31 from the ozone-treated sludge flow-out pipe 15. Thus, the ozone-treated sludge 103 is decomposed by the activated sludge and
10 the amount of the excess sludge to be discarded can be reduced. In another configuration, the ozone-treated sludge 103 is put into the anaerobic digestion tank 34 from the ozone-treated sludge flow-out pipe 15. Thus, the volume reduction effect due to anaerobic digestion in the anaerobic
15 digestion tank 34 can be improved.

[0040] Embodiment 5

A sludge treatment device according to embodiment 5 will be described. FIG. 12 is a schematic view showing an overall structure of a sewage treatment device according to
20 embodiment 5. In embodiment 5, a process performed when the ozone-treated sludge 103 has not been stored in the ozone-treated sludge tank 13 in the sewage treatment device 300 in FIG. 10 which uses the sludge treatment device 202 described in embodiment 2, will be described.

25 [0041] The ozone-treated sludge tank 13 and the anaerobic

digestion tank 34 are connected via a digestion sludge circulation pipe 39, and the digestion sludge 108 in the anaerobic digestion tank 34 is extracted and stored into the ozone-treated sludge tank 13. A low-viscosity solution
5 supplied from the ozone-treated sludge tank 13 to the mixing tank 3 is the digestion sludge 108. In operation of the sewage treatment device 300, there is a case where the ozone-treated sludge 103 has not been stored in the ozone-treated sludge tank 13. Therefore, instead of the ozone-treated
10 sludge 103, the digestion sludge 108 is used, and the concentrated excess sludge 110 and the digestion sludge 108 are mixed in the mixing tank 3, to generate the mixed sludge 102. In FIG. 12, the viscosity of the digestion sludge 108 is lower than the viscosity of the concentrated excess sludge
15 110 to be subjected to the ozone treatment. Therefore, the digestion sludge 108 can be used as a low-viscosity solution. [0042] The mixed sludge 102 is modified by the ozone gas 104, and then all returned as the ozone-treated sludge 103 to the anaerobic digestion tank 34. The digestion sludge 108
20 initially stored into the ozone-treated sludge tank 13 is all returned as the ozone-treated sludge 103 including the digestion sludge 108, to the anaerobic digestion tank. Therefore, the amount of the digestion sludge originally stored in the anaerobic digestion tank 34 is not increased.
25 In addition, even if the digestion sludge 108 and the

concentrated excess sludge 110 are mixed in the ozone treatment, the liquid amount of the ozone-treated sludge 103 put into the anaerobic digestion tank 34 is the same as in the case of putting the concentrated excess sludge 110 therein.

[0043] In the above description, the configuration in which the digestion sludge 108 is used in the ozone treatment when the ozone-treated sludge 103 has not been stored in the ozone-treated sludge tank 13, has been shown. However, another configuration may be adopted. When the ozone-treated sludge 103 has not been stored in the ozone-treated sludge tank 13, the excess sludge 100 may be stored into the ozone-treated sludge tank 13, and ozone gas may be injected into the stored excess sludge 100 by an air diffuser or the like, thereby generating the ozone-treated sludge 103 in the ozone-treated sludge tank 13.

[0044] As described above, the sludge treatment device according to embodiment 5 is configured such that the digestion sludge 108 extracted from the anaerobic digestion tank 34 is used as a low-viscosity solution when the ozone-treated sludge 103 has not been stored in the ozone-treated sludge tank 13. Therefore, there is nothing to be newly added and put into the anaerobic digestion tank 34, other than the concentrated excess sludge 110. Thus, dilution of the concentration of the digestion sludge 108 stored in the

anaerobic digestion tank 34 is suppressed, and the volume reduction treatment can be efficiently performed.

[0045] Embodiment 6

A sludge treatment device 205 according to
5 embodiment 6 will be described. FIG. 13 is a schematic view showing an overall structure of the sludge treatment device which is a part of a sewage treatment device according to embodiment 6. The sludge treatment device 205 according to embodiment 6 is configured such that a pressure gauge 20 and
10 a flowmeter 21 are provided to the sludge treatment device 202 of embodiment 2, to perform control so that operation motive power for the sludge treatment device 205 becomes constant.

[0046] The pressure gauge 20 for measuring the pressure
15 inside the pipe and the flowmeter 21 for measuring the flow speed of the mixed sludge 102 are provided to the mixed sludge supply pipe 8. Measured values of the pressure gauge 20 and the flowmeter 21 are transmitted to a control device 22. The control device 22 controls the excess sludge supply
20 pump 4, the ozone gas generator 12, and the ozone-treated sludge circulation pump 17.

[0047] Control of the sludge treatment device 205 using the pressure gauge 20 and the flowmeter 21 will be described. Generation of fine ozone gas bubbles inside the ejector 9 is
25 performed through control of the flow speed of the mixed

sludge 102 flowing through the narrow portion 9a and the flow rate of the ozone gas 104 injected into the ejector 9. The flow speed of the mixed sludge 102 can be measured using the flowmeter 21. In addition, ease of flow relevant to the flow speed, which depends on the viscosity of the mixed sludge 102 flowing through the ejector 9, can be measured using the pressure gauge 20. That is, by performing control so that the values of the pressure gauge 20 and the flowmeter 21 each become constant, it is possible to operate the sludge treatment device 205 at constant operation motive power. On the basis of the measured values of the pressure gauge 20 and the flowmeter 21, the control device 22 controls the flow rate of the stored sludge supplied from the excess sludge tank 1 to the mixing tank 3, and the flow rate of the ozone-treated sludge 103 supplied from the ozone-treated sludge tank 13 to the mixing tank 3.

[0048] A specific control procedure when the concentration of the stored sludge has increased will be described. In operation of the sludge treatment device 205, if the concentration of the stored sludge is increased, the concentration of the mixed sludge 102 passing through the ejector 9 is increased. Thus, the mixed sludge 102 acts as a resistance in the narrow portion 9a, so that the pressure value measured by the pressure gauge 20 increases and the flow rate value measured by the flowmeter 21 decreases. By

increasing the ratio of the ozone-treated sludge 103 in the mixing tank 3, it is possible to restore the changed pressure value and flow rate value to those in normal operation.

Accordingly, the control device 22 controls the excess sludge supply pump 4 so as to decrease the flow rate of the excess sludge supply pump 4, thereby decreasing the amount of the stored sludge to be supplied to the mixing tank 3 and increasing the ratio of the ozone-treated sludge 103 in the mixing tank 3. In addition, it is also possible to increase the ratio of the ozone-treated sludge 103 in the mixing tank 3 by the control device 22 controlling the ozone-treated sludge circulation pump 17 so as to increase the flow rate of the ozone-treated sludge circulation pump 17 and increase the amount of the ozone-treated sludge 103 to flow out to the mixing tank 3. Alternatively, both of the above controls may be performed in parallel.

[0049] Further, by performing control for changing the concentration and the flow rate of the ozone gas 104 to be injected from the ozone gas generator 12 into the ejector 9 in accordance with the flow rate of the mixed sludge 102, it is possible to perform the volume reduction treatment on the excess sludge 100 efficiently with a used ozone amount optimized.

[0050] As described above, the sludge treatment device 205 according to embodiment 6 is configured such that the flow

rate of the stored sludge supplied from the excess sludge tank 1 to the mixing tank 3 and the flow rate of the ozone-treated sludge 103 supplied from the ozone-treated sludge tank 13 to the mixing tank 3 are controlled on the basis of measured values of the pressure gauge 20 and the flowmeter 21 provided to the mixed sludge supply pipe 8. Thus, operation motive power required for the sludge treatment can be stably kept at a constant value.

[0051] Although the disclosure is described above in terms of various exemplary embodiments and implementations, it should be understood that the various features, aspects, and functionality described in one or more of the individual embodiments are not limited in their applicability to the particular embodiment with which they are described, but instead can be applied, alone or in various combinations to one or more of the embodiments of the disclosure.

It is therefore understood that numerous modifications which have not been exemplified can be devised without departing from the scope of the present disclosure. For example, at least one of the constituent components may be modified, added, or eliminated. At least one of the constituent components mentioned in at least one of the preferred embodiments may be selected and combined with the constituent components mentioned in another preferred embodiment.

DESCRIPTION OF THE REFERENCE CHARACTERS

[0052]	1 excess sludge tank
	2 excess sludge supply pipe
5	3 mixing tank
	4 excess sludge supply pump
	5 low-viscosity solution tank
	6 low-viscosity solution supply pipe
	7 low-viscosity solution supply pump
10	8 mixed sludge supply pipe
	9 ejector
	9a narrow portion
	10 mixed sludge supply pump
	11 ozone supply pipe
15	12 ozone gas generator
	13 ozone-treated sludge tank
	14 ozone-treated sludge flow-in pipe
	15 ozone-treated sludge flow-out pipe
	16 ozone-treated sludge circulation pipe
20	17 ozone-treated sludge circulation pump
	18 mixer
	19 connection portion
	20 pressure gauge
	21 flowmeter
25	22 control device

	31	aeration tank
	32	settling tank
	33	concentrating machine
	34	anaerobic digestion tank
5	35	dewatering machine
	36	first excess sludge storage pipe
	37	second excess sludge storage pipe
	38	third excess sludge storage pipe
	39	digestion sludge circulation pipe
10	100	excess sludge
	101	low-viscosity solution
	102	mixed sludge
	103	ozone-treated sludge
	104	ozone gas
15	105	sewage
	106	treated water
	107	return sludge
	108	digestion sludge
	109	volume-reduced sludge
20	110	concentrated excess sludge
	200	sludge treatment device
	300	sewage treatment device
	301	water treatment device
	302	dewatering treatment device

CLAIMS

[1] A sewage treatment device comprising:

a water treatment device which performs treatment on sewage to obtain treated water;

5 a dewatering treatment device which performs volume reduction treatment of reducing an amount of excess sludge generated in the treatment; and

a sludge treatment device which reduces an amount of the excess sludge generated in the treatment and/or an
10 amount of concentrated excess sludge generated in the volume reduction treatment, wherein

the sludge treatment device includes

an excess sludge tank which stores the excess sludge and/or the concentrated excess sludge as stored
15 sludge,

an ozone gas generator which generates ozone gas,

a mixing unit which mixes a low-viscosity solution and the stored sludge supplied from the excess
20 sludge tank, to generate mixed sludge,

an ejector which generates ozone-treated sludge by injecting the ozone gas into the mixed sludge flowing out from the mixing unit, and

an ozone-treated sludge tank which stores the
25 ozone-treated sludge flowing out from the ejector, and

the low-viscosity solution is a solution having a lower viscosity than the stored sludge.

[2] The sewage treatment device according to claim 1,
5 further comprising a low-viscosity solution tank which stores the low-viscosity solution to be supplied to the mixing unit.

[3] The sewage treatment device according to claim 1,
wherein
10 the mixing unit and the ozone-treated sludge tank are connected via an ozone-treated sludge circulation pipe,
and

the ozone-treated sludge is supplied as the low-viscosity solution to the mixing unit.

15

[4] The sewage treatment device according to any one of claims 1 to 3, wherein

the mixing unit is a mixing tank which generates the mixed sludge by stirring or circulating the stored sludge
20 and the low-viscosity solution.

[5] The sewage treatment device according to any one of claims 1 to 3, wherein

the mixing unit is a mixer which generates the
25 mixed sludge from the stored sludge and the low-viscosity

solution by using a mechanical mechanism.

[6] The sewage treatment device according to claim 5,
wherein

5 the mixer is a static mixer.

[7] The sewage treatment device according to claim 3,
wherein

 the mixing unit and the ejector are connected via a
10 mixed sludge supply pipe,

 the sewage treatment device further comprising a
control device which controls a flow rate of the stored
sludge to be supplied from the excess sludge tank to the
mixing unit and/or a flow rate of the ozone-treated sludge to
15 be supplied from the ozone-treated sludge tank to the mixing
unit, on the basis of measured values of a pressure gauge and
a flowmeter provided to the mixed sludge supply pipe.

[8] The sewage treatment device according to any one of
20 claims 1 to 7, wherein

 the excess sludge stored in the excess sludge tank
is excess sludge extracted from an aeration tank which treats
the sewage into the excess sludge through an activated sludge
process and/or a settling tank which separates the treated
25 water from the excess sludge extracted from the aeration tank

in the water treatment device, and

the concentrated excess sludge stored in the excess
sludge tank is concentrated excess sludge extracted from a
concentrating machine which concentrates the excess sludge
5 extracted from the settling tank in the dewatering treatment
device.

[9] The sewage treatment device according to claim 8,
wherein

10 the aeration tank and the ozone-treated sludge tank
are connected via an ozone-treated sludge flow-out pipe for
putting the ozone-treated sludge into the aeration tank.

[10] The sewage treatment device according to claim 8,
15 wherein

an anaerobic digestion tank which treats the
concentrated excess sludge by digestion sludge in the
dewatering treatment device, and the ozone-treated sludge
tank, are connected via an ozone-treated sludge flow-out pipe
20 for putting the ozone-treated sludge into the anaerobic
digestion tank.

[11] The sewage treatment device according to claim 10,
wherein

25 the anaerobic digestion tank and the ozone-treated

sludge tank are connected via a digestion sludge circulation pipe, and

the low-viscosity solution to be supplied to the mixing unit is the digestion sludge extracted from the anaerobic digestion tank to the ozone-treated sludge tank.

[12] A sewage treatment method comprising the steps of:
mixing a low-viscosity solution, and stored sludge formed from excess sludge and/or concentrated excess sludge generated in treatment on sewage, to generate mixed sludge;
injecting ozone gas bubbles generated from ozone gas, into the mixed sludge; and
modifying the excess sludge and/or the concentrated excess sludge contained in the mixed sludge by the ozone gas bubbles, to generate ozone-treated sludge, wherein
the low-viscosity solution is a solution having a lower viscosity than the stored sludge.