

DESCRIPTION

SLUDGE TREATMENT DEVICE AND SLUDGE TREATMENT METHOD

TECHNICAL FIELD

5 [0001] The present invention relates to a sludge treatment device and a sludge treatment method used for sludge treatment, and in particular, relates to treatment of sludge solubilized by ozone gas.

10 BACKGROUND ART

[0002] Conventionally, as a treatment method for sewage, food waste water, livestock waste water, or the like containing organic sludge substances, an activated sludge method using microorganisms called activated sludge is widely
15 used. In the activated sludge method, a large amount of sludge containing microorganisms, called excess sludge, occurs during a treatment process. Therefore, the volume of the large amount of excess sludge is reduced, and then the excess sludge is subjected to landfill or incineration.

20 [0003] In recent years, effective utilization of the excess sludge as a fuel source has been attempted. In particular, the following approach is being taken: generated excess sludge is subjected to an anaerobic digestion treatment to generate methane gas, and the methane gas is
25 utilized for combustion or gas electric power generation,

thereby recovering thermal energy and electric energy.

[0004] In order to increase the amount of energy recovered from the excess sludge by the anaerobic digestion treatment, it is necessary to increase the amount of generation of the methane gas. Therefore, the anaerobic digestion treatment is performed after the excess sludge is solubilized by a physical or chemical method, thereby effectively generating methane gas. As a conventional physical sludge solubilizing method, organic substance decomposition using ozone gas, molecular weight reduction by ultrasonic wave, and the like are known. As a chemical sludge solubilizing method, a method of dissolving the sludge by an acid, an alkali, an enzyme, or the like is known.

[0005] In the case of subjecting excess sludge to an anaerobic digestion treatment, it is necessary to concentrate the excess sludge in advance so as to reduce the volume thereof, in order to enhance treatment efficiency. This is because a residence time of about 20 days to 50 days is needed for the anaerobic digestion treatment, and therefore, if the anaerobic digestion treatment is performed without volume reduction of the excess sludge, a large-size anaerobic digestion treatment tank is needed. As the concentration method for concentrating excess sludge so as to reduce the volume thereof, a floatation separation method, a flocculation sedimentation method, or the like is used.

Sludge treatment devices and sludge treatment methods for solubilizing excess sludge by ozone gas and reducing the volume thereof as described above are disclosed as follows.

5 [0006] An organic waste liquid such as sewage is once stored in a storage tank, and then introduced into an aeration tank. In the aeration tank, the organic waste liquid is brought into contact with activated sludge under an aerobic condition and thus is subjected to an aerobic
10 biological treatment. The treated liquid undergoes solid-liquid separation into treated water and excess sludge in a settling tank. The clarified treated water is subjected to water-quality adjustment in a water-quality adjustment tank, and then discharged to outside of the treatment system. Of
15 the excess sludge, a necessary amount as an aerobic microorganism source is returned to the aeration tank via a return path, and the rest of the excess sludge is subjected to a concentration treatment by a concentration device such as a centrifugal separator. Next, the concentrated excess
20 sludge after the concentration treatment is transferred to an ozone treatment tank and is subjected to an ozone treatment. In the ozone treatment tank, ozone generated by an ozone generating device is introduced to perform a solubilizing treatment for the concentrated excess sludge. Next, the
25 excess sludge solubilized in the ozone treatment tank is,

without being returned to an aerobic biological treatment, transferred to an anaerobic digestion treatment device to be subjected to an anaerobic digestion treatment, and the generated gas is recovered while stabilization and volume
5 reduction of the excess sludge are performed (see, for example, Patent Document 1).

[0007] In order to reduce the volume of excess sludge in a final settling basin of a sewage treatment plant, an excess sludge pipe is connected to an ozone treatment device. At a
10 stage subsequent to the ozone treatment device, a bubble recovering device is connected via a sludge pipe. A chemical liquid supply device is connected to a bubble recovery pipe of the bubble recovering device. At a stage subsequent to the chemical liquid supply device, a sludge concentration
15 treatment device is connected via a chemical liquid treated sludge pipe, and a concentrated sludge pipe is provided to the sludge concentration treatment device. The concentrated sludge pipe is connected to a phosphorus recovery treatment device. The phosphorus recovery treatment device is
20 connected via a phosphorus removed sludge pipe to a digestion treatment device provided with a digested sludge pipe.

Performing a concentration treatment for bubbles (sludge) recovered from the bubble recovery pipe at the stage subsequent to the ozone treatment device leads to increase in
25 the phosphorus recovery rate and the digestion gas generation

amount, whereby the sludge generation amount can be decreased (see, for example, Patent Document 2).

CITATION LIST

5 PATENT DOCUMENT

[0008] Patent Document 1: Japanese Laid-Open Patent Publication No. 2002-1398 (paragraphs [0019] to [0021], FIG. 1)

Patent Document 2: International Publication No.

10 WO2015/166784A1 (paragraphs [0011], [0016], FIG. 1)

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0009] In the conventional sludge treatment device and
15 sludge treatment method as described in Patent Document 1, the excess sludge is concentrated before transferred to the ozone treatment tank. The solid material concentration in this concentrated excess sludge is in a range of 20 g/L to 50 g/L. The excess sludge concentrated in such a manner does
20 not have fluidity. Therefore, if ozone gas is injected, it is difficult to uniformly mix the ozone gas and the excess sludge. Thus, the ozone gas forms a gas accumulated part in the concentrated excess sludge. Ozone gas subsequently injected gathers to the gas accumulated part, so that the
25 volume of the gas accumulated part increases.

[0010] If a gap that allows the gas to pass to outside of the sludge is formed between the gas accumulated part and the surface of the concentrated excess sludge, the gas flows out from the gas accumulated part to outside of the concentrated
5 sludge. Inside such a gas accumulated part having a large volume, the efficiency of contact between the concentrated excess sludge and the ozone gas is deteriorated, and therefore the gas coming out of the gas accumulated part contains a large amount of unreacted ozone gas. Also, by
10 stirring the concentrated excess sludge, it is possible to improve the efficiency of contact between the concentrated excess sludge and the ozone gas inside the gas accumulated part. However, owing to stirring, the gas accumulated part might reach the surface of the concentrated excess sludge, so
15 that the ozone gas inside the gas accumulated part becomes highly likely to come out from the surface of the concentrated excess sludge. Thus, if ozone gas is injected into the concentrated excess sludge, some ozone gas remains unreacted, and therefore the amount of ozone gas needed for
20 solubilizing the concentrated sludge increases, leading to a problem of cost increase.

[0011] In the conventional sludge treatment device and sludge treatment method as described in Patent Document 2, the high-concentration excess sludge solubilized by an ozone
25 treatment is subjected to a concentration treatment for the

purpose of volume reduction. As a flocculant used in such a concentration treatment, a polymer flocculant having a high viscosity is used. Therefore, if such a polymer flocculant is added to the high-concentration excess sludge solubilized by an ozone treatment, the flocculant does not diffuse in the excess sludge, and thus the efficiency of concentration is deteriorated. As a result, a large amount of sludge remains in the water separated from the excess sludge and thus there is a problem that the amount of organic substances in the concentrated excess sludge decreases.

[0012] The present invention has been made to solve the above problems, and an object of the present invention is to provide a sludge treatment device and a sludge treatment method that enable decrease of the usage amount of ozone gas and increase of the amount of organic substances in the flocculated sludge.

SOLUTION TO THE PROBLEMS

[0013] A sludge treatment device according to the present invention includes: a first treatment unit to which a sludge containing liquid is supplied and which injects ozone gas into the sludge containing liquid, to generate first sludge; and a second treatment unit which is provided at a stage subsequent to the first treatment unit and which adds a first flocculant to the first sludge supplied from the first

treatment unit and mixes the first sludge and treated water,
to generate second sludge. A sludge treatment method
according to the present invention includes: an ozone
reaction step of injecting ozone gas into a sludge containing
5 liquid to generate bubbles, thereby separating the sludge
containing liquid into bubble-like first sludge and a residue
liquid; and a first addition step of extracting the separated
first sludge and adding a first flocculant thereto, and also
mixing the first sludge and treated water, to generate second
10 sludge.

EFFECT OF THE INVENTION

[0014] In the sludge treatment device and the sludge
treatment method according to the present invention, the
15 first sludge generated by solubilizing the sludge containing
liquid by ozone gas is mixed with the first flocculant and
the treated water so as to be flocculated. Thus, the usage
amount of the ozone gas can be decreased and the amount of
organic substances in the flocculated sludge can be increased.
20

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] [FIG. 1] FIG. 1 is a schematic configuration
diagram showing a sludge treatment device according to
embodiment 1 of the present invention.
25 [FIG. 2] FIG. 2 is a flowchart showing the

procedure in the sludge treatment device and a sludge treatment method according to embodiment 1 of the present invention.

[FIG. 3] FIG. 3 illustrates a process of
5 flocculating sludge using the sludge treatment device and the sludge treatment method according to embodiment 1 of the present invention.

[FIG. 4] FIG. 4 illustrates a process of
flocculating sludge using the sludge treatment device and the
10 sludge treatment method according to embodiment 1 of the present invention.

[FIG. 5] FIG. 5 illustrates a process of
flocculating sludge using the sludge treatment device and the
sludge treatment method according to embodiment 1 of the
15 present invention.

[FIG. 6] FIG. 6 shows the details of an experiment for confirming a sludge flocculation effect using the sludge treatment device and the sludge treatment method according to embodiment 1 of the present invention.

20 [FIG. 7] FIG. 7 shows a result of the experiment for confirming the sludge flocculation effect using the sludge treatment device and the sludge treatment method according to embodiment 1 of the present invention.

[FIG. 8] FIG. 8 is a schematic configuration
25 diagram showing a sludge treatment device according to

embodiment 2 of the present invention.

[FIG. 9] FIG. 9 is a schematic configuration diagram showing a sludge treatment device according to embodiment 3 of the present invention.

5 [FIG. 10] FIG. 10 is a schematic configuration diagram showing a sludge treatment device according to embodiment 4 of the present invention.

[FIG. 11] FIG. 11 is a schematic configuration diagram showing a sludge treatment device according to
10 embodiment 5 of the present invention.

[FIG. 12] FIG. 12 is a schematic configuration diagram showing treatment systems of the sludge treatment device according to embodiment 5 of the present invention.

[FIG. 13] FIG. 13 shows the liquid amount of
15 digested sludge Y to be treated by a dehydrator of the sludge treatment device according to embodiment 5 of the present invention.

DESCRIPTION OF EMBODIMENTS

20 [0016] Embodiment 1

Hereinafter, a sludge treatment device 100 and a sludge treatment method according to embodiment 1 of the present invention will be described with reference to the drawings.

25 FIG. 1 is a schematic configuration diagram showing

the sludge treatment device 100 according to embodiment 1 of the present invention.

FIG. 2 is a flowchart showing the implementation procedure of the sludge treatment device 100 and the sludge treatment method according to embodiment 1 of the present invention.

FIG. 3 illustrates a process of flocculating sludge in a sludge containing liquid X.

FIG. 4 illustrates a process subsequent to the process shown in FIG. 3.

FIG. 5 illustrates a process subsequent to the process shown in FIG. 4.

FIG. 6 shows the details of an experiment for confirming a sludge flocculating effect using the sludge treatment device 100 and the sludge treatment method according to embodiment 1 of the present invention.

FIG. 7 shows a result of the experiment for confirming the sludge flocculating effect using the sludge treatment device 100 and the sludge treatment method according to embodiment 1 of the present invention.

[0017] As shown in FIG. 1, the sludge treatment device 100 of the present embodiment 1 includes: an ozone reaction tank 10 as a first treatment unit; and an addition tank 20 as a second treatment unit provided at a stage subsequent to the ozone reaction tank 10.

The ozone reaction tank 10 is connected to a bubble generator 1, and by the bubble generator 1, microbubbles of ozone gas Q are injected into a solution and the like stored in the ozone reaction tank 10.

5 As the bubble generator 1, for example, a diffuser pipe or a diffuser plate having micropores, an ejector, or the like can be used. An outflow port 2 is provided at an upper part of the ozone reaction tank 10, and a flow path 3 communicates with the outflow port 2. An outflow port 4 is
10 provided at a lower part of the ozone reaction tank 10, and a flow path 5 communicates with the outflow port 4.

[0018] The addition tank 20 includes: a separation tank 21 as a first tank connected to the flow path 3; and a mixing tank 22 as a second tank provided at a stage subsequent
15 thereto. The separation tank 21 and the mixing tank 22 are connected via a pipe 23. The mixing tank 22 is connected to the flow path 5.

A first storage unit 25 for storing a first flocculant G1 which is an inorganic flocculant is connected
20 to the separation tank 21 so that the first flocculant G1 can be added to a solution and the like in the separation tank 21. The separation tank 21 has a stirrer 24 as a defoaming unit.

[0019] At a stage subsequent to the addition tank 20, a concentration tank 30 as a third treatment unit is provided.
25 The mixing tank 22 and the concentration tank 30 are

connected via a flow path 26. A second storage unit 35 for storing a second flocculant G2 which is an organic flocculant is connected to the concentration tank 30 so that the second flocculant G2 can be added to a liquid and the like in the concentration tank 30.

As the concentration tank 30, a floatation separation device, a flocculation sedimentation device, or the like is used.

At a stage subsequent to the concentration tank 30, an anaerobic digestion tank 40 for performing an anaerobic treatment using anaerobic microorganisms is provided. The concentration tank 30 and the anaerobic digestion tank 40 are connected via a flow path 31.

[0020] Hereinafter, a sludge flocculating process using the sludge treatment device 100 configured as described above will be described with reference to FIG. 1 and FIG. 2.

At a stage preceding the sludge treatment device 100, an aerobic treatment tank (not shown in FIG. 1) for performing an aerobic treatment using aerobic microorganisms is provided. A sludge containing liquid X which occurs in the aerobic treatment tank and contains excess sludge is supplied to the ozone reaction tank 10 of the sludge treatment device 100 of the present embodiment, and is stored in the ozone reaction tank 10.

[0021] Next, in the ozone reaction tank 10, microbubbles

of ozone gas Q generated by the bubble generator 1 are injected into the stored sludge containing liquid X. The injected ozone gas Q dissolves an organic component contained in the sludge containing liquid X. The ozone gas Q foams at the interface between the sludge containing liquid X and bubbles of the ozone gas Q, and sludge that is the dissolved organic component adheres to the bubble film, thus generating bubble sludge A1 as bubble-like first sludge at the upper part of the sludge containing liquid X. The bubble sludge A1 is repeatedly generated at the upper part of the sludge containing liquid X by the sludge containing liquid X and the ozone gas Q being continuously supplied into the ozone reaction tank 10. Therefore, newly generated bubble sludge A1 pushes up the previously generated bubble sludge A1 to the upper part of the ozone reaction tank 10, and thus the bubble sludge A1 rises inside the ozone reaction tank 10 and fills the inside of the ozone reaction tank 10.

[0022] While the bubble sludge A1 rises in the ozone reaction tank 10, the ozone gas Q present inside the bubble sludge A1 continuously dissolves sludge adhering to the bubble films of the bubble sludge A1. When the bubble sludge A1 rising in the ozone reaction tank 10 reaches the upper part of the ozone reaction tank 10, the bubble sludge A1 flows out to the flow path 3 through the outflow port 2.

A residue liquid Z constituted of water contained

in the sludge containing liquid X that has not adhered to the bubble sludge A1 is accumulated at the lower part of the ozone reaction tank 10.

In this way, in the ozone reaction tank 10, sludge
5 in the sludge containing liquid X is solubilized by ozone gas Q, whereby the sludge containing liquid X is separated into the bubble sludge A1 formed by the solubilized sludge adhering to bubbles, and the residue liquid Z (ozone reaction step, step S1).

10 [0023] The bubble sludge A1 extracted from the sludge containing liquid X as described above is transferred through the flow path 3 to the separation tank 21 of the addition tank 20 provided at the stage subsequent to the ozone reaction tank 10.

15 In the separation tank 21, the bubbles contained in the supplied bubble sludge A1 are broken by the stirrer 24 (defoaming step, step S2). Thus, in the separation tank 21, by breaking the bubbles in the bubble sludge A1, the bubble sludge A1 is separated into a waste gas H composed of the
20 residual gas contained in the bubble sludge A1, and a sludge solution A2 as first sludge containing the solubilized sludge.

[0024] Next, in the separation tank 21, the first flocculant G1 which is an inorganic flocculant and is stored in the first storage unit 25 is added to the sludge solution
25 A2.

In the separation tank 21, in order to uniformly mix the first flocculant G1 with the sludge solution A2, the first flocculant G1 is added while the sludge solution A2 is stirred by the stirrer 24. The sludge solution A2 to which
5 the first flocculant G1 has been added is extracted from the separation tank 21 and transferred to the mixing tank 22 through the pipe 23.

Next, in the mixing tank 22, the residue liquid Z accumulated at the lower part of the ozone reaction tank 10
10 is mixed as treated water with the sludge solution A2, thereby generating a mixed sludge solution B as second sludge.

[0025] In this way, in the separation tank 21 and the mixing tank 22 of the addition tank 20, the first flocculant G1 is added to the sludge solution A2 and the residue liquid
15 Z is mixed therewith, whereby the mixed sludge solution B is generated (first addition step, step S3).

The mixed sludge solution B generated in the addition tank 20 as described above is transferred through the flow path 26 to the concentration tank 30 as the third
20 treatment unit provided at the stage subsequent to the addition tank 20.

[0026] Next, in the concentration tank 30, the second flocculant G2 which is an organic polymer flocculant and is stored in the second storage unit 35 is added to the mixed
25 sludge solution B supplied from the addition tank 20 (second

addition step, step S4). By the second flocculant G2, a
sludge component in the mixed sludge solution B is
flocculated and thus is separated into concentrated sludge C
as third sludge, and a separated liquid N. The separated
5 liquid N is discharged through the flow path 32.

The generated concentrated sludge C is transferred
through the flow path 31 to the anaerobic digestion tank 40
provided at the stage subsequent to the mixing tank 22.

[0027] Next, in the anaerobic digestion tank 40, the
10 supplied concentrated sludge C is subjected to an anaerobic
treatment using anaerobic microorganisms (digestion step,
step S5). The concentrated sludge C is decomposed by the
anaerobic microorganisms, whereby methane gas T occurs.

[0028] In the above description, the case where the
15 addition tank 20 includes two tanks, i.e., the separation
tank 21 and the mixing tank 22, has been shown, but the
addition tank 20 is not limited thereto. For example, the
addition tank 20 may include only one tank, and addition of
the first flocculant G1 and mixing of the residue liquid Z
20 may be performed in the one tank. In this case, the residue
liquid Z may be first mixed with the sludge solution A2 and
then the first flocculant G1 may be added, or the residue
liquid Z and the first flocculant G1 may be mixed at the same
time.

25 [0029] Next, with reference to FIGS. 3, 4, 5, a process in

which sludge in the sludge containing liquid X is efficiently flocculated by the sludge treatment device 100 and the sludge treatment method of the present embodiment will be described in detail.

5 The sludge and water contained in the sludge containing liquid X shown in FIG. 3(a) are separated by ozone gas Q into the bubble sludge A1 (FIG. 3(b)) and the residue liquid Z (FIG. 3(c)).

[0030] As shown in FIG. 3(b), sludge adhering to the
10 bubble films of the bubble sludge A1 is solubilized by the ozone gas Q and becomes minute particles.

 Most of the sludge contained in the sludge containing liquid X adheres to the bubble films of the bubble sludge A1, and therefore is not left in the residue liquid Z.
15 Thus, since water in the sludge containing liquid X is separated as the residue liquid Z, the bubble sludge A1 becomes a high-concentration solubilized sludge solution.

[0031] Next, as shown in FIG. 3(d), by breaking the bubbles in the bubble sludge A1, the sludge solution that has
20 formed the bubble films of the bubbles is accumulated at the lower part of the separation tank 21, whereby a high-concentration sludge solution A2 is generated.

 Next, as shown in FIG. 4(e), when the first flocculant G1 is added to the sludge solution A2, the first
25 flocculant G1 and sludge particles of the sludge solution A2

are bound together to generate flocculated particles R1.

[0032] The efficiency of generation of the flocculated particles R1 depends on the probability of contact between the first flocculant G1 and the sludge particles of the

5 sludge solution A2. However, the sludge solubilized by ozone gas Q has a particle diameter of 1 micron or less, and thus is micronized. Therefore, the inorganic first flocculant G1 having a small particle size is used to improve the contact efficiency.

10 As the inorganic first flocculant G1 for flocculating the micronized sludge, for example, poly ferric sulfate or poly aluminum chloride may be used.

[0033] In general, an inorganic flocculant is positively charged, and therefore is electrically attracted to minute
15 particles having negatively charged surfaces, thereby forming a large flocculation core. The sludge particles micronized by ozone gas Q as shown in the present embodiment have negatively charged surfaces, and therefore are readily attracted to the inorganic flocculant which is positively
20 charged. Thus, in the case of adding the inorganic flocculant, the sludge micronized by the ozone gas Q can be efficiently flocculated.

[0034] In addition, since the first flocculant G1 is added to the sludge solution A2 in a state in which the bubbles in
25 the bubble sludge A1 have been broken, the efficiency of

contact between the sludge particles and the first flocculant G1 is higher than in the case of adding the first flocculant G1 to sludge with bubbles remaining. By thus improving the efficiency of generation of the flocculated particles R1, the
5 usage amount of the first flocculant G1 can be decreased.

[0035] Next, as shown in FIG. 4(f), the residue liquid Z is mixed with the sludge solution A2 to which the first flocculant G1 has been added, whereby the mixed sludge solution B is generated. The sludge solution A2 is watered
10 by the residue liquid Z, whereby the distance between the flocculated particles R1 in the sludge solution A2 is expanded.

[0036] Next, as shown in FIG. 5(g), the second flocculant G2 which is an organic polymer flocculant having a large-
15 particle structure is added. The second flocculant G2 which is a polymer flocculant has a very high viscosity, but is uniformly dispersed in the mixed sludge solution B having a viscosity decreased by being watered by the residue liquid Z.

As described above, in the mixed sludge solution B,
20 the distance between the flocculated particles R1 is expanded and the second flocculant G2 is uniformly dispersed.

Therefore, the efficiency of binding between the second flocculant G2 and the flocculated particles R1 is improved. Thus, the second flocculant G2 is efficiently bound with the
25 flocculated particles R1 and forms further large flocculated

particles R2.

[0037] Next, as shown in FIG. 5(h) and FIG. 5(i), the mixed sludge solution B is separated into the concentrated sludge C formed by the flocculated particles R2, and the
5 separated liquid N which is a water component in the mixed sludge solution B. Thus, the concentrated sludge C formed by the flocculated sludge component is obtained.

In this way, the second flocculant G2 effectively forms the flocculated particles R2. Thus, the amount of the
10 sludge (organic substances) that has failed to be flocculated by the second flocculant G2 and is left in the separated liquid N is small and the concentrated sludge C containing a large amount of organic substances is obtained.

[0038] Hereinafter, a result of an experiment for
15 verifying that, by using the sludge treatment device 100 and the sludge treatment method of the present embodiment, the sludge (organic substance amount) left in the separated liquid N discharged from the concentration tank 30 is decreased, i.e., the efficiency of sludge recovery by the
20 flocculant is improved, will be described with reference to FIG. 6 and FIG. 7.

The sludge flocculation property was evaluated by an organic substance concentration (TVS concentration) in the separated liquid N discharged from the concentration tank 30.
25 The lower the concentration of organic substances contained

in the separated liquid N is, the higher the recovery rate of the sludge (organic substances) by the flocculant is and the larger the amount of organic substances in the concentrated sludge C is.

5 [0039] In the experiment, a sludge containing liquid X having a suspended substance concentration (SS concentration) of 5 g/L was used, and ozone gas Q was injected into the sludge containing liquid X such that the ozone absorption amount was 60 mgO₃/gSS.

10 As the first flocculant G1, poly ferric sulfate was used.

As the second flocculant, a cationic powdered polymer flocculant MP-184 manufactured by HYMO CORPORATION was used. The polymer flocculant MP-184 was dissolved in
15 water so as to be prepared as a solution of 0.3 wt%, and sludge was concentrated in the concentration tank 30.

In the concentration tank 30, in the second addition step, in order to concentrate the flocculated sludge, filtration was performed with a mesh of 75 microns, thereby
20 performing separation into concentrated sludge C and a separated liquid N.

[0040] FIG. 6 shows a flocculation treatment condition and the addition concentrations of the first flocculant G1 and the second flocculant G2, for each condition number.

25 FIG. 7 shows the organic substance concentration

(TVS concentration) in the separated liquid N discharged from the concentration tank 30, for each condition number.

[0041] The flocculation treatment condition of condition number 1 corresponds to conventional technology, in which the
5 sludge containing liquid X was concentrated using only a polymer flocculant which is the second flocculant.

As shown in FIG. 7, the TVS concentration in the separated liquid N was about 1.6 g/L.

[0042] The flocculation treatment condition of condition
10 number 2 corresponds to conventional technology, in which mixed sludge obtained by mixing a residue liquid and sludge solubilized by ozone gas Q was concentrated using only a polymer flocculant which is the second flocculant.

As shown in FIG. 7, the TVS concentration in the
15 separated liquid N was increased to about 2.7 g/L because the solubilized sludge was mixed.

[0043] The flocculation treatment condition of condition number 3 corresponds to the sludge treatment device 100 and the sludge treatment method of the present embodiment, in
20 which the first flocculant G1 and the second flocculant G2 were added to mixed sludge obtained by mixing a residue liquid Z and sludge solubilized by ozone gas Q, thereby concentrating the mixed sludge.

As shown in FIG. 7, the TVS concentration in the
25 separated liquid N was decreased to about slightly greater

than 1.2 g/L, and thus the flocculation property was improved as compared to the conditions of flocculation numbers 1, 2.

[0044] The flocculation treatment condition of condition number 4 corresponds to the sludge treatment device 100 and
5 the sludge treatment method of the present embodiment, in which, after the first flocculant G1 was added to sludge solubilized by ozone gas Q, the residue liquid Z was mixed therewith to obtain mixed sludge, and the second flocculant G2 was added to the mixed sludge, thereby concentrating the
10 mixed sludge.

As shown in FIG. 7, the TVS concentration in the separated liquid N was decreased to about 1.2 g/L, and thus the flocculation property was improved as compared to the condition of condition number 3.

15 [0045] In the flocculation treatment condition of condition number 5, the same treatment method as in the above condition number 4 was used and only the addition amount of the first flocculant G1 was increased.

As shown in FIG. 7, the TVS concentration in the
20 separated liquid N was decreased to about 1.1 g/L, and thus the flocculation property was improved as compared to the condition number 4.

[0046] From the result of the experiment, it is found that, by adding the inorganic first flocculant G1 to the sludge
25 solution A2 solubilized by ozone gas Q and mixing the residue

liquid Z therewith, and further adding the organic polymer second flocculant G2 thereto, the organic substance concentration in the separated liquid N is decreased, and thus the flocculants can be efficiently utilized.

5 In addition, from comparison between the condition number 3 and the condition number 4, it is found that the organic substance concentration in the separated liquid N is more decreased in the case of condition number 4 in which the residue liquid Z was mixed after the first flocculant G1 was
10 added.

 This is because the flocculated particles R1 obtained by binding of the first flocculant G1 and the minute particles of solubilized sludge are kept in a flocculated state even when the residue liquid Z is mixed thereafter.

15 [0047] In the sludge treatment device 100 and the sludge treatment method of the present embodiment configured as described above, in the ozone reaction step S1, the sludge containing liquid X is solubilized by ozone gas Q to generate the bubble sludge A1 (sludge solution A2). By solubilizing
20 the sludge in this way, an effect of promoting the subsequent anaerobic treatment can be obtained, and the generation amount of methane gas T can be increased.

 Without performing flocculation of sludge at the stage preceding the ozone reaction tank 10, flocculation of
25 sludge is performed at the stage subsequent to the ozone

reaction tank 10. Thus, the sludge containing liquid X in the ozone reaction tank 10 has fluidity, and therefore the efficiency of contact between the ozone gas Q and the sludge containing liquid X increases. This allows decrease in the usage amount of the ozone gas Q.

[0048] In the first addition step, the first flocculant G1 (in the present embodiment, inorganic flocculant) having a small particle size is added to the bubble sludge A1 (sludge solution A2) micronized by ozone gas Q, to perform flocculation. Thus, the micronized sludge can be effectively flocculated.

In the first addition step, the residue liquid Z is mixed with the bubble sludge A1 (sludge solution A2), to generate the mixed sludge solution B. By adding the residue liquid Z in this way, the flocculation efficiency of the second flocculant G2 to be added later can be improved.

[0049] The addition tank 20 includes the separation tank 21 for adding the first flocculant G1, and at the subsequent stage, the mixing tank 22 for adding the residue liquid Z, so that the residue liquid Z is mixed with the sludge solution A2 to which the first flocculant G1 has been added. The flocculated particles R1 obtained by binding of the first flocculant G1 and the minute particles of the solubilized sludge are kept in a flocculated state even when the residue liquid Z is mixed thereafter. Therefore, it is possible to

obtain flocculated sludge containing a large amount of organic substances.

[0050] The bubbles in the bubble sludge A1 supplied from the ozone reaction tank 10 are broken, whereby the bubble
5 sludge A1 is separated into the waste gas H and the sludge solution A2. Then, the first flocculant G1 is added to the defoamed sludge solution A2. Therefore, the efficiency of contact between the sludge solution A2 and the first flocculant G1 is increased, and the addition amount of the
10 first flocculant G1 can be decreased.

[0051] In the mixing tank 22, the residue liquid Z accumulated in the ozone reaction tank 10 is used as treated water to be added to the sludge solution A2. If the residue liquid Z is utilized in this way, it is not necessary to
15 prepare treated water separately, and thus cost reduction can be achieved.

[0052] In the concentration tank 30, the second flocculant G2 (in the present embodiment, organic polymer flocculant) is added to the mixed sludge solution B generated by adding the
20 residue liquid Z thereto. Thus, the flocculation efficiency of the second flocculant G2 can be improved, and concentrated sludge C containing a large amount of organic substances can be generated. Since a large amount of organic substances is contained in the concentrated sludge C as described above,
25 the generation amount of methane gas in the anaerobic

digestion tank 40 can be increased, whereby larger amounts of thermal energy and electric energy can be obtained.

[0053] In the above description, an example in which an inorganic flocculant is used as the first flocculant G1 has been shown. However, a polymer flocculant containing a polymer as a main component may be used.

In the mixing tank 22, the residue liquid Z accumulated at the lower part of the ozone reaction tank 10 is mixed as treated water with the sludge solution A2. However, tap water or the like may be used as the residue liquid Z.

The case where the sludge treatment device 100 includes the ozone reaction tank 10 and the addition tank 20 has been shown. However, a sludge treatment device including the concentration tank 30 in addition to the ozone reaction tank 10 and the addition tank 20 may be used, or a sludge treatment device further including the anaerobic digestion tank 40 may be used.

[0054] It is noted that, if ozone gas Q continues to be added to the solubilized sludge, the molecular weight is further reduced so that the solubilized sludge is decomposed into an organic acid. If the solubilized sludge is decomposed to a molecular level in this way, it is difficult to flocculate the solubilized sludge by a flocculant. The micro-particle size of the solubilized sludge that can be

flocculated by a flocculant is in a range of 1 micron to submicron. In order to keep solubility to this level, it is necessary to control the amount of ozone gas Q to be absorbed by the sludge. The amount of ozone gas Q absorbed by sludge
5 adhering to bubbles in the ozone reaction tank 10 is in a range of 30 mg to 150 mg with respect to an SS concentration of 1 g/L of the sludge, and optimally, in a range of 50 mg to 100 mg.

[0055] Embodiment 2

10 Hereinafter, embodiment 2 of the present invention will be described focusing on difference from the above embodiment 1, with reference to the drawings. The same parts as those in the above embodiment 1 are denoted by the same reference characters and the description thereof is omitted.

15 FIG. 8 is a schematic configuration diagram showing a sludge treatment device 200 according to embodiment 2 of the present invention.

In embodiment 1, the first storage unit 25 for storing the first flocculant G1 which is an inorganic
20 flocculant is connected to the separation tank 21. In the present embodiment, the first storage unit 25 is connected to the pipe 23 connecting the separation tank 21 and the mixing tank 22.

In embodiment 1, the separation tank 21 is provided
25 with the stirrer 24 as a defoaming unit. In the present

embodiment, the separation tank 21 is provided with an antifoaming agent addition tank 224 as a defoaming unit.

[0056] In the separation tank 21 of the present embodiment, in the defoaming step, an antifoaming agent is added to the
5 bubble sludge A1 by the antifoaming agent addition tank 224 so as to break bubbles contained in the bubble sludge A1, thereby generating the sludge solution A2.

In the first addition step of the present embodiment, the first flocculant G1 is added to the sludge
10 solution A2 flowing in the pipe 23. Since the first flocculant G1 is added to the flowing sludge solution A2 as described above, the first flocculant G1 can be efficiently mixed with the sludge solution A2.

[0057] The sludge treatment device 200 and the sludge
15 treatment method of the present embodiment configured as described above provide the same effects as in the above embodiment 1, so that the usage amount of ozone gas Q can be decreased and the amount of organic substances in the flocculated sludge can be increased.

20 In addition, since the first flocculant G1 is added to the sludge solution A2 flowing in the pipe 23, the first flocculant G1 and the sludge solution A2 can be efficiently mixed. Therefore, it becomes unnecessary to provide the stirrer 24 for mixing the first flocculant G1 and the sludge
25 solution A2 in the separation tank 21, and thus the device

cost can be decreased.

[0058] Embodiment 3

Hereinafter, embodiment 3 of the present invention will be described focusing on difference from the above
5 embodiment 2, with reference to the drawings. The same parts as those in the above embodiment 1 are denoted by the same reference characters and the description thereof is omitted.

FIG. 9 is a schematic configuration diagram showing a sludge treatment device 300 according to embodiment 3 of
10 the present invention.

In the present embodiment, the pipe 23 is provided with a mixer 326 for mixing the sludge solution A2 and the first flocculant G1 in the pipe 23. The first storage unit 25 is connected to the pipe 23 via the mixer 326.

15 [0059] As the mixer 326, an ejector, a static mixer, or the like can be used.

In the case of the ejector, a throttling portion is provided to the flow path so as to allow increase/decrease of the pressure of the liquid. When another liquid or gas is
20 injected into the flow path in which the pressure of the liquid sharply varies, the injected liquid or gas is mixed with the liquid flowing through the ejector by the sharp pressure variation.

In the case of the static mixer, plates for
25 dividing or mixing the flow path are provided, and these

plates produce a stirring effect.

[0060] The sludge treatment device 300 and the sludge treatment method of the present embodiment configured as described above provide the same effects as in the above
5 embodiment 2, so that the usage amount of ozone gas Q can be decreased and the amount of organic substances in the flocculated sludge can be increased.

In addition, since the first flocculant G1 is added to the sludge solution A2 flowing in the pipe 23, the first
10 flocculant G1 and the sludge solution A2 can be efficiently mixed.

It is noted that, if the ejector or the static mixer is used, it becomes unnecessary to provide motive power such as a stirrer for mixing, leading to cost reduction.

15 [0061] Embodiment 4

Hereinafter, embodiment 4 of the present invention will be described focusing on difference from the above embodiment 1, with reference to the drawings. The same parts as those in the above embodiment 1 are denoted by the same
20 reference characters and the description thereof is omitted.

FIG. 10 is a schematic configuration diagram showing a sludge treatment device 400 according to embodiment 4 of the present invention.

An aerobic treatment unit 50 which is provided at a
25 stage preceding the sludge treatment device 400 and which

performs an aerobic treatment using aerobic microorganisms, is shown together with the sludge treatment device 400.

[0062] The aerobic treatment unit 50 includes: an initial settling tank 51 for storing a waste liquid such as sewage
5 and settling solid materials in the waste liquid; an aerobic digestion tank 52 as a treatment tank for performing an aerobic treatment for the waste liquid from which the solid materials have been removed; and a final settling tank 53 for storing a sludge containing liquid X containing excess sludge
10 generated in the aerobic digestion tank 52.

The sludge containing liquid X containing excess sludge generated in the final settling tank 53 is supplied to the ozone reaction tank 10, as in embodiment 1. Further, the sludge containing liquid X or a sludge containing liquid P
15 which is initially settled sludge generated in the initial settling tank 51 is supplied to the mixing tank 22 via a storage tank 54.

Thus, the mixing tank 22 is configured so that the sludge solution A2 obtained by solubilizing the sludge
20 containing liquid X by ozone gas Q, and the sludge containing liquids X, P which have not been solubilized, are flocculated at the same time in the mixing tank 22.

[0063] In the case where there is a large amount of sludge containing liquid X needed to undergo anaerobic digestion, if
25 a solubilizing treatment by ozone gas Q is performed for all

the sludge containing liquid X supplied from the aerobic treatment unit 50, a long treatment time might be required, leading to increase in treatment cost. In such a case, if the sludge treatment device 400 of the present embodiment is applied, of the sludge containing liquid X supplied from the aerobic treatment unit 50, a certain amount of sludge containing liquid X that allows a desired amount of methane gas to be obtained in the anaerobic digestion tank 40 is supplied to the ozone reaction tank 10 and is subjected to a solubilizing treatment, while the rest of the sludge containing liquid X is not subjected to the solubilizing treatment. Thus, it becomes possible to shorten the treatment time and decrease the treatment cost.

[0064] Embodiment 5

Hereinafter, embodiment 5 of the present invention will be described focusing on difference from the above embodiment 1, with reference to the drawings. The same parts as those in the above embodiment 1 are denoted by the same reference characters and the description thereof is omitted.

FIG. 11 is a schematic configuration diagram showing a sludge treatment device 500 according to embodiment 5 of the present invention.

FIG. 12 is a block diagram showing an ozone reaction system composed of the ozone reaction tank 10 and the addition tank 20, a concentration system composed of the

concentration tank 30, an anaerobic digestion system composed of the anaerobic digestion tank 40, and a dehydration system composed of a dehydrator 60 in the sludge treatment device 500 according to embodiment 5 of the present invention, and
5 shows the amount of sludge treated in each treatment system.

In the present embodiment, a dehydrator 60 as a fourth treatment unit is provided at a stage subsequent to the anaerobic digestion tank 40 shown in embodiment 1.

[0065] The sludge treatment device 500 of the present
10 embodiment includes the ozone reaction tank 10, the addition tank 20, the concentration tank 30, the anaerobic digestion tank 40, a digested sludge extraction pipe 61 as a digested sludge pipe, and a digested sludge return pipe 62 as a digested sludge pipe.

15 [0066] The digested sludge extraction pipe 61 is for extracting, from the anaerobic digestion tank 40, digested sludge Y generated through the anaerobic treatment in the anaerobic digestion tank 40. One end of the digested sludge extraction pipe 61 is connected to the anaerobic digestion
20 tank 40, and the other end is connected to the dehydrator 60. One end of the digested sludge return pipe 62 for branching the digested sludge Y flowing in the digested sludge extraction pipe 61 is connected to a middle part of the digested sludge extraction pipe 61. The other end of the
25 digested sludge return pipe 62 is connected to the ozone

reaction tank 10. In a middle part of the digested sludge return pipe 62, a digested sludge pump 63 is provided for transferring the digested sludge Y in the digested sludge return pipe 62 to the ozone reaction tank 10.

5 [0067] In the sludge treatment device 500 configured as described above, the concentrated sludge C is supplied to the anaerobic digestion tank 40 through the same process as that shown in embodiment 1. Then, when the concentrated sludge C is subjected to an anaerobic treatment, the digested sludge Y
10 constituted of a digested matter of the concentrated sludge C and a liquid containing anaerobic microorganisms occurs in the anaerobic digestion tank 40. Thus, the liquid amount of the digested sludge Y stored in the anaerobic digestion tank 40 increases.

15 [0068] In order to efficiently perform the anaerobic treatment in consideration of the volume of the anaerobic digestion tank 40, it is necessary to keep constant the liquid amount of the digested sludge Y stored in the anaerobic digestion tank 40. Therefore, the same amount of
20 digested sludge Y as the concentrated sludge C supplied from the concentration tank 30 to the anaerobic digestion tank 40 needs to be extracted from the anaerobic digestion tank 40. Therefore, the same amount of digested sludge Y as the concentrated sludge C supplied to the anaerobic digestion
25 tank 40 is extracted from the anaerobic digestion tank 40 by

the digested sludge extraction pipe 61. A part of the extracted digested sludge Y is returned as returned digested sludge YA to the ozone reaction tank 10 through the digested sludge return pipe 62. The rest of the extracted digested
5 sludge Y is supplied to the dehydrator 60 through the digested sludge extraction pipe 61.

[0069] The digested sludge Y supplied to the dehydrator 60 is subjected to dehydration and then subjected to incineration.

10 As for the returned digested sludge YA returned to the ozone reaction tank 10, an organic component thereof is to be dissolved by ozone gas Q as described below.

[0070] In the ozone reaction tank 10, ozone gas Q is injected into the sludge containing liquid X and the returned
15 digested sludge YA that has been returned. The injected ozone gas Q dissolves an organic component contained in the sludge containing liquid X and an organic component contained in the returned digested sludge YA.

The returned digested sludge YA extracted from the
20 anaerobic digestion tank 40 contains organic substances micronized by being decomposed by anaerobic microorganisms, and organic substances having a larger particle size than the micronized organic substances. The larger-particle-size organic substances contained in the returned digested sludge
25 YA are dissolved by ozone gas Q together with the organic

substances contained in the sludge containing liquid X, and then adhere to the generated bubble sludge A1 which is the first sludge, so as to be further dissolved.

[0071] Thus, the organic substances contained in the
5 sludge containing liquid X and the larger-particle-size organic substances contained in the returned digested sludge YA are transferred to the separation tank 21 of the addition tank 20 while being dissolved in a state of adhering to the bubble sludge A1.

10 As in embodiment 1, in the separation tank 21, bubbles in the bubble sludge A1 are broken, whereby the bubble sludge A1 is separated into the waste gas H and the sludge solution A2 as the first sludge that has been solubilized. Then, in the separation tank 21, the first
15 flocculant G1 is added to the sludge solution A2.

[0072] On the other hand, the minute-particle organic substances contained in the returned digested sludge YA, after being dissolved by injection of ozone gas Q, does not adhere to the bubble sludge A1 because they are minute, and
20 the minute-particle organic substances are mixed as returned sludge YB into the residue liquid Z. The residue liquid Z containing the returned sludge YB is supplied to the mixing tank 22 of the addition tank 20. Then, in the mixing tank 22, the first flocculant G1 is added to the residue liquid Z
25 containing the returned sludge YB. Then, in the mixing tank

22, the residue liquid Z containing the returned sludge YB is mixed as treated water with the sludge solution A2 supplied from the separation tank 21, whereby the mixed sludge solution B as the second sludge is generated.

5 [0073] In the concentration tank 30, as in embodiment 1, the second flocculant G2 which is an organic polymer flocculant is added to the mixed sludge solution B supplied from the addition tank 20. Thus, the mixed sludge solution B is separated into the separated liquid N, and the
10 concentrated sludge C as the third sludge in which the sludge component is flocculated.

In this way, the larger-particle organic substances and the minute-particle organic substances contained in the returned digested sludge YA are flocculated by the first
15 flocculant G1 in the addition tank 20, and then mixed into the concentrated sludge C in the concentration tank 30.

The generated concentrated sludge C is transferred to the anaerobic digestion tank 40, to be subjected to an anaerobic treatment using anaerobic microorganisms. The
20 digested sludge Y newly occurring as a result of the anaerobic treatment is partially returned to the ozone reaction tank 10, and the rest thereof is supplied to the dehydrator 60.

[0074] It is noted that, since the returned digested
25 sludge YA returned to the ozone reaction tank 10 is separated

into the concentrated sludge C and the separated liquid N in the concentration tank 30, the solid material concentration in the concentrated sludge C is higher than the solid material concentration in the digested sludge Y. The solid material concentration in the digested sludge Y in the anaerobic digestion tank 40 is in a range of 15 g/L to 25 g/L. On the other hand, the solid material concentration in the concentrated sludge C obtained from the concentration tank 30 is in a range of 30 g/L to 60 g/L.

[0075] Hereinafter, with reference to FIG. 12, the liquid amount of the digested sludge Y supplied to the dehydrator 60 will be described for the case of returning the digested sludge Y to the ozone reaction tank 10 and the case of not returning the digested sludge Y.

In FIG. 12, the liquid amount of the returned digested sludge YA returned to the ozone reaction system is denoted by V1, the liquid amount of the digested sludge Y to be treated by the dehydrator 60 is denoted by V2, and the liquid amount of the sludge containing liquid X is denoted by X1.

The separated liquid amount of the sludge containing liquid X separated in the concentration system is denoted by NX, and the separated liquid amount of the returned digested sludge YA is denoted by NV.

The amount of the concentrated sludge obtained

after the sludge containing liquid X is concentrated in the concentration system is denoted by CX, and the amount of the concentrated sludge of the returned digested sludge YA is denoted by CV.

5 [0076] As described above, in order to keep constant the liquid amount of the digested sludge Y stored in the anaerobic digestion tank 40, the same amount of the digested sludge Y as the concentrated sludge C supplied to the anaerobic digestion tank 40 is extracted from the anaerobic
10 digestion tank 40.

[0077] In the case of not returning the digested sludge Y to the ozone reaction tank 10 ($V1 = 0$, $CV = 0$), the amount of the concentrated sludge supplied to the anaerobic digestion tank 40 is the concentrated sludge amount CX of the sludge
15 containing liquid X. Therefore, the liquid amount of the digested sludge Y extracted from the anaerobic digestion tank 40 is CX, and thus the liquid amount V2 of the digested sludge Y to be treated by the dehydrator 60 is equal to CX.

$V2 = CX$ (Expression 1, case of not returning
20 digested sludge Y)

[0078] On the other hand, in the case of returning the digested sludge Y to the ozone reaction tank 10, the amount of the concentrated sludge supplied to the anaerobic digestion tank 40 is $CV + CX$. Therefore, the liquid amount
25 of the digested sludge Y extracted from the anaerobic

digestion tank 40 is $CV + CX$.

Therefore, the liquid amount $V2$ of the digested sludge Y to be treated by the dehydrator 60 is $CV + CX - V1$.

$V2 = CV + CX - V1$ (Expression 2, case of returning
5 digested sludge Y)

[0079] Here, in the concentration system, the liquid amount $V1$ of the returned digested sludge YA is separated into the separated liquid amount NV and the concentrated sludge amount CV . Thus, $V1 = CV + NV$ (Expression 3) is
10 satisfied.

[0080] From the above Expressions 2 and 3, the liquid amount $V2$ of the digested sludge Y to be treated by the dehydrator 60 is represented as follows.

$V2 = CX - NV$ (Expression 2A, case of returning
15 digested sludge Y)

If $V1$ is increased, NV also increases, and along with this, $V2$ decreases.

It is noted that $CX > NV$ is satisfied.

[0081] From the above Expressions 1 and 2A, it is found
20 that the liquid amount $V2$ of the digested sludge Y to be supplied to the dehydrator 60 is decreased by returning the digested sludge Y in the anaerobic digestion tank 40 to the ozone reaction tank 10.

[0082] It is noted that it is necessary to determine the
25 amounts NV and CX in advance so as to satisfy the above

condition, $CX > NV$. That is, considering the concentration rate in the concentration system in advance, setting is performed so that the amount CX of the concentrated sludge obtained after the sludge containing liquid X is concentrated becomes larger than the separated liquid amount NV of the returned digested sludge YA in the concentration system.

[0083] Hereinafter, the liquid amount $V2$ of the digested sludge Y to be treated by the dehydrator 60 in the case where the compression rate in the concentration system is two times, will be described.

FIG. 13 shows the relationship between the liquid amount $V1$ of the returned digested sludge YA and the liquid amount $V2$ of the digested sludge Y to be treated by the dehydrator 60, in the sludge treatment device 500 according to the present embodiment 5.

This case assumes that, in the concentration system, the liquid amount $V1$ of the returned digested sludge YA is concentrated to two times the original concentration, and the separated liquid amount NV and the concentrated sludge amount CV become equal to each other.

[0084] Since the separated liquid amount NV of the returned digested sludge YA and the concentrated sludge amount CV of the returned digested sludge YA are equal to each other, the liquid amount $V1$ of the returned digested sludge YA is represented as $V1 = 2 \times NV$ (Expression 4).

From the above Expressions 2A and 4, the liquid amount V2 supplied to the dehydrator 60 is represented as follows.

$$V2 = -V1/2 + CX \text{ (Expression 2B)}$$

5 [0085] In the above Expression 2B, when V1 is 0, V2 is equal to CX.

If the liquid amount V1 of the returned digested sludge YA is set to be equal to the concentrated sludge amount CX, V2 becomes equal to CX/2, so that the liquid
10 amount V1 of the digested sludge Y supplied to the dehydrator 60 is halved.

[0086] In the sludge treatment device 500 and the sludge treatment method of the present embodiment configured as described above, the digested sludge Y occurring in the
15 anaerobic digestion tank 40 is returned as the returned digested sludge YA to the ozone reaction tank 10, whereby the returned digested sludge YA is to be subjected to a compression treatment in the concentration tank 30 provided at the stage subsequent to the ozone reaction tank 10.

20 Thus, the liquid amount V2 of the digested sludge Y supplied to the dehydrator 60 can be decreased. Therefore, the dehydrator 60 can be downsized, whereby space saving and cost reduction can be achieved.

[0087] Further, not only the organic substances contained
25 in the sludge containing liquid X but also the organic

substances contained in the returned digested sludge YA are solubilized by ozone gas Q and then subjected to an anaerobic treatment. Thus, the generation amount of methane gas T in the anaerobic treatment can be increased.

5 Further, the minute organic substances contained in the digested sludge Y are to be contained as the returned sludge YB in the residue liquid Z, after being dissolved by ozone gas Q. Then, the first flocculant G1 is added to the residue liquid Z containing the returned sludge YB, whereby
10 the minute organic substances are flocculated, and thus concentrated sludge C containing a large amount of organic substances can be obtained.

[0088] It is noted that, within the scope of the present invention, the above embodiments may be freely combined with
15 each other, or each of the above embodiments may be modified or simplified as appropriate.

CLAIMS

[1] A sludge treatment device comprising:

a first treatment unit to which a sludge containing liquid is supplied and which injects ozone gas into the

5 sludge containing liquid, to generate first sludge; and

a second treatment unit which is provided at a stage subsequent to the first treatment unit and which adds a first flocculant to the first sludge supplied from the first treatment unit and mixes the first sludge and treated water,

10 to generate second sludge, wherein

the second treatment unit includes:

a first tank to which the first sludge is supplied from the first treatment unit; and

a second tank which is provided at a stage
15 subsequent to the first tank and which mixes the treated water with the first sludge supplied from the first tank.

[2] The sludge treatment device according to claim 1,
wherein

20 the first flocculant is an inorganic flocculant.

[3] The sludge treatment device according to claim 1 or
2, wherein

25 the first tank includes a defoaming unit for

breaking bubbles contained in the first sludge.

[4] The sludge treatment device according to any one of claims 1 to 3, further comprising a first storage unit

5 storing the first flocculant, wherein

the first storage unit is connected to the first tank and adds the first flocculant to the first sludge in the first tank.

10 [5] The sludge treatment device according to any one of claims 1 to 3, further comprising:

a first storage unit storing the first flocculant;

and

a pipe connecting the first tank and the second

15 tank, wherein

the first storage unit is connected to the pipe and adds the first flocculant to the first sludge in the pipe.

[6] The sludge treatment device according to claim 1 or

20 2, wherein

the second treatment unit mixes, as the treated water, a residue liquid accumulated in the first treatment unit, with the first sludge.

25 [7] The sludge treatment device according to any one of

claims 1 to 3, wherein

the second tank mixes, as the treated water, a residue liquid accumulated in the first treatment unit, with the first sludge.

5

[8] The sludge treatment device according to claim 65, wherein

the pipe is provided with a mixer for mixing the first sludge and the first flocculant in the pipe.

10

[9] The sludge treatment device according to any one of claims 1 to 8, further comprising a third treatment unit which is provided at a stage subsequent to the second treatment unit and which adds a second flocculant to the second sludge supplied from the second treatment unit, to generate third sludge.

15

[10] The sludge treatment device according to claim 9, wherein

20

the second flocculant is an organic polymer flocculant.

[11] The sludge treatment device according to claim 9 or 10, further comprising an anaerobic digestion tank which is provided at a stage subsequent to the third treatment unit

25

and which performs an anaerobic treatment using anaerobic microorganisms, for the third sludge supplied from the third treatment unit, to generate methane gas.

5 [12] The sludge treatment device according to claim 11, further comprising a digested sludge pipe which supplies digested sludge occurring through the anaerobic treatment in the anaerobic digestion tank, to a fourth treatment unit provided at a stage subsequent to the anaerobic digestion
10 tank, and which also returns the digested sludge as returned digested sludge to the first treatment unit, wherein

 the first treatment unit injects the ozone gas into the sludge containing liquid and the returned digested sludge, to generate the first sludge, and returned sludge to be
15 contained in a residue liquid accumulated in the first treatment unit.

[13] The sludge treatment device according to claim 12, wherein

20 the second treatment unit adds the first flocculant to the first sludge supplied from the first treatment unit and the residue liquid containing the returned sludge, and mixes, as the treated water, the residue liquid containing the returned sludge, with the first sludge, to generate the
25 second sludge.

[14] The sludge treatment device according to any one of claims 1 to 5, further comprising an aerobic treatment unit for generating the sludge containing liquid, wherein

5 the aerobic treatment unit supplies the sludge containing liquid to the first treatment unit and the second tank.

[15] A sludge treatment device comprising:

10 a first treatment unit to which a sludge containing liquid is supplied and which injects ozone gas into the sludge containing liquid, to separate the sludge containing liquid into first sludge and a residue liquid; and

a second treatment unit which is provided at a
15 stage subsequent to the first treatment unit and which adds a first flocculant to the first sludge supplied from the first treatment unit and mixes the first sludge and the residue liquid separated as treated water from the sludge containing liquid, to generate second sludge.

20

[16] A sludge treatment method comprising:

an ozone reaction step of injecting ozone gas into a sludge containing liquid to generate bubbles, thereby separating the sludge containing liquid into bubble-like
25 first sludge and a residue liquid;

a step of supplying the first sludge separated from the sludge containing liquid, to a first tank; and

a first addition step of extracting the separated first sludge and adding a first flocculant thereto, and also
5 mixing the first sludge and treated water, to generate second sludge, wherein

in the first addition step, the first sludge in the first tank is supplied to a second tank provided at a stage subsequent to the first tank, and the treated water is mixed
10 with the first sludge in the second tank, to generate the second sludge.

[17] The sludge treatment method according to claim 16, wherein

15 in the first addition step, an inorganic flocculant is added as the first flocculant.

[18] The sludge treatment method according to claim 16 or 17, further comprising a defoaming step of breaking the
20 bubble-like first sludge to defoam the same, wherein

in the first addition step, the first flocculant is added to the defoamed first sludge.

[19] The sludge treatment method according to any one of
25 claims 16 to 18, further comprising a second addition step of

adding a second flocculant to the second sludge.

[20] The sludge treatment method according to any one of claims 16 to 19, wherein

5 in the first addition step, the residue liquid is mixed as the treated water with the first sludge.

[21] A sludge treatment method comprising:

 an ozone reaction step of injecting ozone gas into
10 a sludge containing liquid to generate bubbles, thereby separating the sludge containing liquid into bubble-like first sludge and a residue liquid; and

 a first addition step of extracting the separated first sludge and adding a first flocculant thereto, and also
15 mixing the first sludge and the residue liquid separated as treated water from the sludge containing liquid, to generate second sludge.