ON-SITE TREATMENT METHOD OF GROUND FOOD WASTES

TECHNICAL FIELD

The present invention relates to a method for the on-site treatment of ground food wastes, in which the food wastes are separated from kitchen water before or after delivery so as to minimize their volume, and then treated in a small-scale treatment system. More particularly, the present invention relates to a treatment method in which food wastes from group residential facilities, such as apartment buildings and tenement houses, group kitchen facilities, such as restaurants, and homes, are ground by a grinder at a generation site, such as a kitchen, without being passed through human hands, transferred to a solid-liquid separator located near the generation site, separated from kitchen water in the separator, and then the separated food wastes are treated in a secondary treatment system.

BACKGROUND ART

It is fact that food wastes in Korea are generated in such a large amount that resources of eight trillion won are annually squandered. The food wastes in Korea have two aspects of both resources and wastes unlike other countries, it become difficult to treat them. For this reason, according to statistical data of the year 2,000 prepared by the Korean Ministry of Environment, 5,600 tons of a total 11,350 tons of food wastes are recycled as feedstuffs and composts, which indicates that the recycling rate of the food wastes is 49.3% in total.

According to the existing treating method, food wastes with good quality are mainly used as feedstuffs as they are, and otherwise they are subjected to on-site treatment or post-collection treatment in the following concrete ways. The

United States utilizes a disposer, Japan utilizes drying and microbial fermentation, and Europe employs composting, but Korean homes from which 64% of total food wastes are generated mostly depend on treatment after separation and collection.

In the case of the food wastes generated from restaurants, systems for performing weight reduction and recycling as resource using hot air drying and fermentation were installed and managed several years ago, but most of them are not currently managed due to excessive power costs required to have odor and water evaporated, and insufficient services. A post-collection treatment method depends on the recycling of food wastes as feedstuffs and composts, but such feedstuffs and composts encounter a difficulty in use due to a sanitary problem and a salt problem, respectively.

Recently, an anaerobic digestion process in addition to the recycling of food wastes as feedstuffs and composts is being adopted. Problems with the recycling of food wastes as feedstuffs and composts are as described above, and to perform the anaerobic digestion process in cities, treating the food wastes alone or in a mixture with sewage sludge is being examined, and in a small-scale apartment buildings, the process is being used in the form of a septic tank. Thus, its usefulness becomes greater gradually to increase the amount of food wastes treated by this process. For example, there are known a system for the integrated treatment of living sewage and kitchen wastes (Korean patent registration No. 10-280934), and a system for treating food wastes and living sewage together with excretions (Korean patent publication No. 10-2000-032344). Also, there is known a method for treating organic wastes (food wastes) using aerobic microorganisms, water, air and hydrogen peroxide (Korean patent registration No. 10-266089). However, such systems are either characterized by the fact that food wastes are treated together with sewage without separation, after transfer from a generation source, or Korean patent registration No. 10-266089 does not specially adopt a sanitary transfer method.

Meanwhile, there is known a method where a separate pipeline is installed, and ground food wastes are transferred by means of a vacuum pump, and then

fermented and dried to reduce their weight (Korean patent registration No. 10-0192561). However, this method has problems that a large-capacity facility is required due to the installation of the separate pipeline and the vacuum pump, and also a complex process is required in which water used in washing the pipeline should be separated from food wastes, and then the sewage should be secondarily treated in a septic tank.

DISCLOSURE OF INVENTION

Accordingly, the present inventors have conducted studies in an attempt to solve the above-mentioned problems occurring in the prior art, and consequently, developed a method of completely treating food wastes on-site even by a small-capacity system whether a separate pipeline is installed or not. On the basis of this point, the prevent invention was perfected.

Therefore, the main object of the present invention is to provide a method of treating food wastes on-site in such a manner that the secondary treatment of residues is not required. The term "on-site" herein means a site not far from a kitchen, which is a place within a building site for individual/tenement houses, a place within an underground room or apartment complex for apartment buildings, and a place near a generation site for group kitchen facilities. Namely, the on-site means a place having the minimum space where a public treatment facility can be installed.

In other words, objects of the present invention are as follows: (1) to transfer food wastes to a treatment site immediately after their generation, so as to prevent the food wastes from decomposing and stinking when stored in a kitchen as in the present time; (2) to separate sewage from the food wastes before or after transport, so as to reduce the amount of the food wastes; (3) to minimize the space required for food waste treatment by using a bioreactor with high performance and high efficiency in view of a limited space in apartment buildings or large-scale restaurants, in order that the space is included in a small space, such as a residual

space in the existing apartment buildings; (4) to convert food wastes into gases, such as methane gas (CH_4) and carbon dioxide (CO_2), and treatment water, which are eco-friendly and thus do not cause the second pollution, such as odors; and (5) to provide this treatment method with economic efficiency and convenience in terms of energy usage and annual treatment cost, as compared to the existing treatment method.

To achieve the above object, in the first embodiment, the present invention provides a method for the on-site treatment of food wastes from group residential facilities and group kitchen facilities, the method comprising the steps of: (a) grinding food wastes by a grinder installed at the lower end of a kitchen sink; (b) separating kitchen sewage from the ground food wastes by a solid-liquid separator A placed downstream of the grinder, the solid-liquid separator A having a structure where a food waste pipeline **5** and a sewage drainpipe **6** are connected to each other by a selection valve **4**, such that when the grinder **2** is not operated, kitchen sewage is transferred to the sewage drainpipe, and when the grinder is operated, the ground food wastes is transferred to the secondary treatment system together with a small amount of kitchen water through the food waste pipeline; and (c) secondarily treating the ground food wastes in a secondary treatment system.

Preferably, the first embodiment of the present invention additionally comprises the step of separating the kitchen sewage used in the transfer of food waste, by a solid-liquid separator B of a cylindrical screen, flat screen or filter type, before transferring the food wastes separated by the solid-liquid separator A to the second treatment system.

In the second embodiment, the present invention provides a method for the on-site treatment of food wastes from group residential facilities or group kitchen facilities, the method comprising the steps of: (a) grinding food wastes by a grinder installed at the lower end of a kitchen sink; (b) transferring the ground food wastes to a solid-liquid separator B of a cylindrical screen, flat screen or filter type, using kitchen water; (c) separating a large amount of sewage from the ground food wastes, using the solid-liquid separator B; (d) transferring the separated sewage to a

drainpipe, and transferring the ground food wastes to the secondary treatment system; and (e) secondarily treating the ground food wastes in a secondary treatment system.

In the third embodiment, the present invention provides a method for the on-site treatment of food wastes from group residential facilities or group kitchen facilities, the method comprising the steps of: (a) separately discharging food wastes and kitchen sewage, using a food waste pipeline separate from a drainpipe, in such a manner that the kitchen sewage is transferred to the drainpipe, and the food wastes are ground by a grinder installed at the lower end of a kitchen sink; (b) transferring the ground food wastes to a solid-liquid separator B of a cylindrical screen, flat screen or filter type, using a small amount of the kitchen sewage; (c) separating a mixture of kitchen sewage and ground food wastes discharged from households, into the kitchen sewage and the food wastes, using the solid-liquid separator B; (d) transferring the separated kitchen sewage to a drainage and transferring the ground food wastes to the secondary treatment system; and (e) secondarily treating the ground food wastes in a secondary treatment system.

The term "secondary treatment system" herein means a biological treatment facility, a septic tank, a discharge facility, drying facility or a recycling treatment facility. For biological treatment, anaerobic treatment or a combination of anaerobic and aerobic treatments is preferably used.

In the present invention, the secondary treatment system preferably comprises: a food waste inlet valve **12**; a cell recycle-type anaerobic reactor **19** filled with a porous ceramic carrier; a cell recycle-type aerobic reactor **20** filled with a porous ceramic carrier; a slurry circulation pump **21**; a unit **23** for injecting air into the aerobic reactor; a gas discharge pipe **24** for discharging methane gas generated by anaerobic treatment and carbon dioxide generated by aerobic treatment; a temperature control unit **22** for controlling the temperature of the treatment system using the generated methane gas; and a sewage discharge valve **15**.

The cylindrical screen-type solid-liquid separator B preferably comprises: a

pipeline **3** into which the ground food wastes and the sewage are introduced; a cylindrical screen **11** consisting of a cylindrically rolled net with a 0.02~2 mm mesh size for separating the sewage from the ground food wastes; a motor **13** for rotating the cylindrical screen; a storage tank **14** for storing the separated sewage; a discharge valve **15** and a drainpipe **8** for discharging the sewage; and means **12** for transferring the food waste solids separated from the sewage by the cylindrical screen, into a secondary treatment system **7**.

In another embodiment, the present invention provides a system for separating food wastes into sewage and solids, the system comprises: a pipeline **3** into which ground food wastes and sewage are introduced; a cylindrical screen **11** consisting of a cylindrically rolled net with a 0.02~2 mm mesh size for separating the sewage from the ground food wastes; a motor **13** for rotating the cylindrical screen; a storage tank **14** for storing the separated sewage; a discharge valve **15** and a drainpipe **8** for discharging the sewage; and means **12** for transferring the food waste solids separated from the sewage by the cylindrical screen, into a secondary treatment system **7**.

Comparison with existing treatment method

In the existing method of treating food wastes in Korea, food wastes are manually separated from a generation source, collected by people, transported to a treatment facility by a car and treated in the treatment facility. Sewage is separated from a generation source, and discharged to a sewage treatment plant (**FIG. 1B**). In USA, food wastes ground by a grinder (disposer) are transported from a kitchen to a sewage treatment plant through a drainpipe together with kitchen sewage (**FIG. 1C**). This method is not permitted in Korea where the existing drainpipe has a narrow width and the sewage treatment plant has insufficient capacity, but in Japan, it is permitted in a limited manner.

In the method of the present invention (**FIG. 1A**), food wastes are ground in a kitchen of residential or cooking facilities, and transferred to a treatment plant not far from the generation source, and then treated in a secondary treatment

system by anaerobic and/or aerobic fermentation, etc.

The inventive method is different from the existing method in the following ways. Namely, in the existing method, food wastes are collected from several generation sites, conveyed to a public treatment plant, and then recycled as feed stuffs and composts or treated anaerobically, but in the inventive method, food wastes are treated directly on-site without performing the collection and conveyance processes. The method in which food wastes are ground by a disposer, transported to a sewage treatment plant together with kitchen swage or living sewage, and then treated in the treatment plant, is now conducted in most of USA households.

The present invention has the most important characteristic in which sewage and ground food wastes are separated from each other using a certain solid-liquid separator, the separated sewage is discharged into a drainpipe maintaining its water quality at the level before mixed with the food wastes, and the separated food wastes are treated on-site using the secondary treatment system of small capacity. When considering that the ratio of ground food wastes to kitchen water or living sewage in one household is 1/250~1/500, if the kitchen sewage and the food wastes are previously separated from each other, the amount of food wastes to be treated in the secondary treatment system can be reduced to the level of about 2~10:1. In other words, the sewage separated using the solid-liquid separator is subjected to simple treatment before discharge to have at least the same or higher water quality than before it is mixed with the ground food wastes. And only small volumes of the separated food wastes are secondarily treated.

For example, if the separated food wastes are treated by anaerobic fermentation, whereas the amount of living sewage from a 100-household apartment building is 50~70 M^3 per day, the volume of separated food wastes is about 200 L/day which can be completely treated even in a small place of a horizontal scale in a basement room or peripheral site without substantially generating odors or byproducts.

Separation methods after grinding

FIG. 2 shows a variety of methods for separating sewage from ground food wastes during the process of transferring the ground food wastes to a treatment site immediately after their generation. In **FIG. 2**, Method A shows the first embodiment of the present invention, in which a grinder **2** and a solid-liquid separator A are installed at the lower end of a kitchen sink of each household, the solid-liquid separator A having a structure where a food waste pipeline **5** and a sewage drainpipe **6** are connected to each other by a selection valve **4**, such that when the grinder is not operated, kitchen sewage is transferred to the sewage drainpipe, and when the grinder is operated, ground food wastes are passed through the food waste pipeline together with a small amount of kitchen water (**FIG. 5**). Food wastes are ground by the grinder, and the ground food wastes are separated from large amount of kitchen sewage by the solid-liquid separator A, and transferred to the secondary treatment system **7**. The food wastes separated by the solid-liquid separator A in each household contain a small amount of kitchen sewage, and if those passed through the solid-liquid separator in each household of an apartment building are combined, the amount of sewage can be increased. To reduce the capacity of the secondary treatment system, it is preferred that a solid-liquid separator B of a cylindrical screen, flat screen or filter type is installed near the secondary treatment system, and the kitchen sewage used for the transfer of food wastes is additionally separated in the solid-liquid separator B, and then the resulting food wastes are transferred to the secondary treatment system.

In **FIG. 2**, Method B shows the second embodiment of the present invention, in which sewage and food wastes generated from various households are collected, and separated into sewage and food wastes by the solid-liquid separator B such as cylindrical screen, flat screen, or filter type. The separated sewage is transferred to a drainpipe, and the separated food wastes are transferred to the secondary treatment system.

In **FIG. 2**, Method C shows the third embodiment of the present invention, in which a pipeline separate from a kitchen food waste inlet port is installed, food

wastes are discharged in a ground form through a grinder installed downstream of the food waste inlet port, and kitchen sewage is discharged directly to a drainage system through the existing drainpipe. The same as Method A, to reduce the capacity of the secondary treatment system, it is preferable for Method C that the solid-liquid separator B of a cylindrical screen, flat screen or filter type is installed near the secondary treatment system, and the kitchen sewage used for the transfer of food wastes is additionally separated in the solid-liquid separator B, and then the resulting food wastes are transferred to the secondary treatment system.

Methods A and C have advantages that a small amount of sewage is required for the transfer of food wastes and the food wastes are not mixed with sewage after grinding, since the food waste pipeline is used. On the other hand, Method B does not require the food waste pipeline such that it can also be applied to the existing apartment buildings. However, in Method B, since food wastes are mixed with kitchen sewage at the ratio of 1/200~1/300 in an apartment building, or as shown in **FIG. 3**, food wastes are diluted in living sewage comprising kitchen sewage, bath water and laundry water, at the ratio of 1/500~1/800, and then transferred, and the separated sewage needs to be treated in such a manner that its water quality is not inferior as compared to before it is mixed with ground food wastes. In both cases, the ground food wastes separated from sewage become a slurry form having a water content of about 90~95%, and their volume becomes about 2~5 times their original volume. Particularly, in Method B, the volume of food wastes is reduced to 1/100~1/250 such that the food wastes can be treated on-site near the generation place, as in Methods A and B.

Treatment process after separation

FIG. 4 shows a concrete way of post-separation treatment. In Method 1, sewage and food wastes are separated from each other by a solid-liquid separator A, after which the sewage is transferred to a drainpipe, and the food wastes are introduced into the biological treatment system, and a small amount of the remaining liquid portion is either discharged to a drainpipe through a water

purification system or used in other purposes. In Method 2, sewage and food wastes are separated from each other by the solid-liquid separator B, and then the sewage is transferred to a drainpipe, and the food wastes are transferred to a septic tank where they are treated together with excretions. If food wastes are introduced into the septic tank, the capacity of the septic tank needs to be increased in order to treat additionally introduced organisms. However, since a small amount of high concentration organisms are introduced, their hydrological retention time in the septic tank is not changed. In Method 3, sewage and food wastes are separated from each other by the solid-liquid separator B, after which the sewage is transferred to the drainpipe, and the food wastes are either transferred to a storage facility to make them composts or feedstuffs or to dry them for recycling, or discharged to the external environment. Method 3 is characterized by the presence of solid residues, and for reference, Method 1 does not require the treatment of solid residues.

Solid-liquid separator

A concrete solid-liquid separation method which is used in the present invention includes: a method where food wastes are separated directly from sewage by the solid-liquid separator A of **FIG. 5** in a household kitchen which is a generation source; and a method where sewage and food wastes are separated from each other by the solid-liquid separator B of **FIG. 6** in a general drainpipe containing sewage from several households.

In the present invention, the solid-liquid separator A is a small-capacity separator placed with a grinder in each household, and the solid-liquid separator B is a large-capacity separator which is installed near the secondary treatment system such that it combines food wastes from several households and then separates them into sewage and food wastes. For example, if a biological treatment facility is located in the basement of an apartment building, the solid-liquid separator B can be installed near the biological treatment facility.

FIG. 5 shows the solid-liquid separator A for separating sewage from food

wastes, which is installed in a kitchen of each household. When a grinder is not operated, a valve **4** is closed such that sewage is not discharged to a food waste pipeline **5**. When the grinder is operated, the valve is opened and the ground food wastes are passed through the food waste pipeline, in which case some water is preferably added so as to facilitate the transfer of the food wastes. The solid-liquid separators shown in **FIG. 6A to 6C** are devices for separating the food wastes mixed with the sewage corresponding to several hundreds to several thousands times the amount of the food wastes. Generally, the sewage generated from a household includes kitchen sewage, bath sewage and laundry sewage, and its total amount reaches 500~800 times the food wastes.

In a 100-household apartment building, 70 tons (100 x 3.5 x 200L) per day can be used, and when 25 tons of toilet water is excluded, 87.5 kg (100 x 3.5 x 0.25) of food wastes are mixed with 45 tons of water so that the ratio of the food wastes to water is 1/514. In this case, it is impossible to recover ground food wastes by 100%, but it has no great problem, since even in a general case where the grinder is not used, soluble organic matter and particulate food wastes with a diameter of less than 5 mm are discharged from a kitchen.

Since most of such particulate organic materials are trapped in the solid-liquid separator B, it is not difficult to adjust chemical oxygen demand (COD) before the discharge of sewage. In other words, the COD of the discharged water treated is expressed as follows:

Total COD of discharged water = [{COD of (FW + KW) before separation} – {COD of particulate (FW + KW)}] ≤ total COD of original KW.

The COD of sewage before placing the grinder can be reduced according to how much of the COD of particulate kitchen wastes (KW) contained in sewage and the COD of particulate food wastes (FW) in ground food wastes are recovered before placing the grinder.

Generally, although a centrifuge can separate a large amount of materials within a short time, it is unsuitable for use in an apartment building having about 100 households due to a lot of noise and power consumption. Considering this

point, the present invention adopts a separator having little noise and low power consumption. **FIG. 6** shows several examples of the solid-liquid separator B. To recover large particles, it is preferable to use a cylindrical screen type (**FIG. 6A**) and a flat screen type (**FIG. 6B**), and in the case where (microparticles) micro-particals need to be recovered, it is preferable to use a filter type (**FIG. 6C**) utilizing a column filled with sand, etc. Since this separator B can be clogged by substances such as vegetable oils, they can be used washing periodically after several hours of use, or two separators are installed such that they can be used alternately.

Biological treatment system

Food wastes are completely biological materials, and thus, can be biologically degraded. However, materials such as bovine bones and shells which require long time for their degradation can be separated and collected before the transfer of food wastes, and materials such as carbohydrates, fats and proteins can be converted into gas or water. Thus, a bioreactor capable of embodying this principle is used in various biological treatment methods, including liquid phase treatment and solid phase treatment (composting) methods.

Among various biological treatment methods, there was considered a method where odors are not generated and residues are a little or easily treated. Thus, in the present invention, there was adopted a liquid phase, anaerobic treatment method with low energy consumption and no residues, rather than a composting method, etc., where solids remain as residues. In the case where better quality sewage needs to be discharged, it is preferable to use the anaerobic treatment method in combination with aerobic treatment. Although if the BOD removal rate of food wastes is increased, the throughput of the food wastes is reduced, the generation of odors caused by organic acids is reduced and little residues remain.

The present invention aimed to remove odors and also to treat well enough for the quality of the water discharged from a bioreactor to be discharged directly to

the external environment. **FIG. 7** shows a biological treatment system, which is characteristically used in the present invention in order to achieve the above objects. This biological treatment system includes anaerobic and aerobic reactors so that it shows the effect of recirculating microorganisms and has the ability to highly purify discharged water. Also, methane gas generated in the biological treatment system is used to maintain the temperature of the reactor (see Example 6 below).

Energy consumption of food waste treatment system according to the present invention

Examination was performed on whether the treatment method of the present invention has economic efficiency and convenience in terms of energy consumption or annual cost for treatment, as compared to the existing method. Namely, examination was performed on additionally required water, chemicals, energy, and a site required for treatment, and the like. Studies conducted in countries utilizing a grinder installed in a kitchen, including USA, show that the amount of water, which is additionally required due to the installation of the grinder in the kitchen, is increased by 2~3% in total amount of water used, but it can be regarded as significant savings in a national point of view when considering that a large amount of water is required to wash salts upon collection and treatment.

In the case of a 100-household apartment building, a part expected to consume energy in the inventive treatment system is first a grinder, which is generally a 3/4-horsepower device and operated for less than one minute per day, which indicates that its energy consumption is insignificant. Also, the energy consumption of a solid-liquid separator is less than 5 kwh/day for 100 households.

In the biological treatment system, if it is a large-scale system, the temperature of the system is maintained by methane gas generated in an anaerobic digester even in the winter season of the temperature of 7 °C and about 80% of the energy remains. If it is for a small-scale apartment building having less than 100 households, its surface area through which heat can be lost is large, so that some energy consumption for maintaining its temperature in the winter season is

expected. Although the quality of water suitable for discharge to the external environment is ensured only by the anaerobic treatment in the biological treatment system, if aerobic treatment is additionally performed in order to ensure better water quality, some additional power consumption is expected.

In the present invention, there are no chemicals that are required for the treatment of food wastes. With regard to a site required for food waste treatment, if the throughput of an anaerobic reactor is taken as 3 kgBOD/m^3·day, for 100 households, the amount of dried organisms is 17.5 kg (87.5% x 0.2) and the volume of the treatment system will be about 6 m^3. This indicates that only the basement of an apartment building or about 6 m^2 of a peripheral site is required for the installation of the inventive system, so that installation is possible.

The present invention is an on-site treatment method considering the convenience and sanitary characteristics of the American-style method using a disposer, and also the circumstances of sewerage systems and sewage treatment plants in Korea. The most fundamental concept of the present invention is characterized by that food wastes are transferred from a kitchen which is a generation site without being passed through human hands, and separated from large amount of household sewage, and then biologically treated. Thus, the present invention eliminates a need for a large space so that it can be practically applied even to a small space, such as apartment buildings, etc.

A small amount of the food wastes separated are either completely treated in the anaerobic biological treatment system, or introduced in a septic tank. In some cases, the amount of food wastes reduced by separation can be discharged and treated in the outside, or recycled by a method, such as composting. In the case of anaerobic treatment, although food wastes are ultimately converted into water, gases and some microorganisms, the microorganisms are prevented from being discharged to the external environment and automatically eradicated, so that the resulting materials discharged out of the reactor are composed of sewage having water quality equivalent to kitchen sewage before mixing with the food wastes, and eco-friendly materials that were anaerobically treated. Methane gas

generated in the treatment reactor serves as fuel for warming the treatment reactor and to produce hot water, so that the inventive method is advantageous in terms of energy utilization as compared to other methods for treating food wastes.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows the comparison between a method of the present invention for treating food wastes and the existing method.

FIG. 2 shows various methods in which food wastes are ground, transferred to a treatment site immediately after their generation, and separated into sewage and solids.

FIG. 3 shows the flow of sewage in the group residential facilities.

FIG. 4 shows various methods where food wastes are separated from sewage and then treated.

FIG. 5 shows a system for completely separating food wastes from kitchen sewage before grinding.

FIG. 6A shows a system for separating ground food wastes from sewage (except for toilet water), which includes a solid-liquid separator B of a cylindrical screen type.

FIG. 6B shows a system for separating ground food wastes from sewage (except for toilet water), which includes a solid-liquid separator B of a flat screen type.

FIG. 6C shows a system for separating ground food wastes from sewage (except for toilet water), which includes a solid-liquid separator B of a sand-filled column type.

FIG. 7 shows a biological treatment system for anaerobically treating ground food wastes from which sewage was separated and removed to reduce the amount of the food wastes.

Reference numerals that are used in the present invention are as follows. **1:** sink; **2:** grinder; **3:** food waste and sewage pipeline; **4:** selection valve; **5:** food

waste pipeline; **6:** sewage pipeline; **7:** secondary treatment system; **8:** drainpipe; **9:** the bottom of the building; **10:** cylindrical screen unit; **11:** cylindrical screen; **12:** food waste inlet valve; **13:** motor; **14:** sewage storage tank; **15:** sewage discharge valve; **16:** flat screen unit; **17:** food waste storage tank; **18:** sand-filled column; **19:** anaerobic reactor; **20:** aerobic reactor; **21:** slurry circulation pump; **22:** temperature control unit; **23:** air injection unit; **24:** gas discharge pipe.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will hereinafter be described in further detail by examples. It will however be obvious to a person skilled in the art that these examples are given for illustrative purpose only, and the scope of the present invention is not limited to or by these examples.

Example 1: Method for treating food wastes from apartment buildings that is newly built and has food waste pipeline

The number of households per building in tenement houses and apartment buildings in Korea ranges from 10 to 200. The amount of food wastes generated in this case is about 0.25 kg (wet weight) per day per person, and their water content is about 80%. The average number of residents per household is about 3.5 people, and the amount of water used per person is about 200 L. For 10 households, about 8.75kg of food wastes are generated per day, and for 200 households, at about 175 kg per day. The amount of water used is about 7 m^3 for 10 households, and about 140 m^3 for 200 households.

If a food waste pipeline is installed, Method C shown in **FIG. 2** can be considered in a kitchen that is a generation site, but it has a shortcoming that a sink has two sewage discharge ports. Thus, as in Method A shown in **FIG. 2**, it is preferable that food wastes are separated from kitchen sewage by the solid-liquid separator A in the kitchen sink having one discharge port. The kitchen sewage is discharged to drainage through the existing sewage pipe (**FIG. 3**), and the food

wastes are added with a small amount of water to facilitate their transfer, and transferred to the secondary treatment system. If necessary, before the food wastes are introduced into the secondary treatment system, a small amount of sewage can also be additionally separated by the solid-liquid separator B.

A biological treatment unit of **FIG. 7** which is placed within Department of Chemical and Biomolecular Engineering of KAIST (Korea Advanced Institute of Science and Technology), and has a volume of 1 m^3 and the capacity to treat food wastes from about 20 households, was operated for one year, and the results showed that the food wastes were completely digested without leaving solid residues, and only methane gas and clear treated water having a COD of about 50 mg/L and a turbidity of about 130 NTU were discharged.

Example 2: Method for treating food wastes from apartment buildings that were built previously and have no food waste pipeline

In a 90-household apartment building where about 3.5 persons per household reside, about 315 persons reside. Food wastes generated in this case are 78.75 kg (about 315 x 0.25 kg/person) per day. Such food wastes have water content of 80% and thus a dry weight is about 15.75 kg. The amount of tap water used daily is about 63 m^3 when calculated from about 200 L/person, but the actual amount thereof is about 80 m^3.

Tap water is used as toilet water, kitchen water, bath water, laundry water and cleaning water. After use, toilet water is about 22.5 M^3/day and separately transferred to a septic tank, and kitchen sewage is about 22.5 M^3/day. Laundry sewage, cleaning sewage and bath sewage are combined with kitchen sewage and about 50~60 M^3/day is discharged. The ratio of combined water to food wastes is 1/630~1/760.

Sewage that is separated from food wastes by the solid-liquid separator B is treated by a filter, etc., to reduce COD such that it is purified as compared to before it is mixed with the food wastes, and then it is discharged. Finally it is combined with toilet sewage passed through a public septic tank, and discharged to a sewage

treatment plant.

Currently, food wastes are stored in a garbage can, and collected in a reservoir within a apartment complex area two or three times a week, to transfer to a public treatment facility outside the apartment building.

Example 3: Method for separating kitchen sewage from ground food wastes in kitchen

Currently, in Korea, discharging the sewage containing ground food wastes into drainpipe is inhibited by the law. In this case, it is preferable that a pipeline for transferring ground food waste is installed in a kitchen, separately from a kitchen sewage discharge pipeline. If two discharge ports are formed in a kitchen sink, and ground food wastes and kitchen sewage are discharged separately, sewage is transferred to a drainpipe, and food wastes is ground by a grinder installed upstream of their discharge port, and then added with some water to facilitate their transfer, and transferred to the secondary treatment system.

As illustrated in Method A of **FIG. 2**, only one discharge port is formed in a sink in which a grinder is installed. The grinder, a T-shaped pipe, one on/off switch, and two sewage pipelines (i.e., food waste pipeline and sewage pipeline) is attached the solid-liquid separator A, such that the food waste pipeline is open only before and after operating the grinder, to transfer the food wastes through the food waste pipeline. If the amount of water is at least two times the amount of ground food wastes, it is sufficient to transfer the food wastes.

Example 4: Method for separating sewage from ground food wastes in public sewage system

Currently, in Korean apartment housings, only one sewage pipe is installed in each kitchen. Kitchen sewage, laundry sewage and bath sewage are discharged to a public sewage system within the apartment buildings, and then discharged to underground (**FIG. 3**). A toilet sewage pipe is managed separately. In the existing apartment buildings having no food waste pipeline installed therein,

Method B of **FIG. 2** is preferably used in a form where 1 part of food wastes are mixed with 500~800 parts of water.

The solid-liquid separator B used in this example is schematically shown in **FIG. 6A**. A cylindrical screen **11** included in the solid-liquid separator B has an inner cylinder with a diameter of about 15 cm, and an outer cylinder with a diameter of about 20 cm and a mesh size of about 0.5 cm. The diameter and mesh size of the cylinders can be adjusted depending on the purpose, and the mesh size ranges preferably from 0.02 mm to 2.0 mm. The food wastes and sewage passed through a pipeline **3** are introduced into a rotating cylindrical screen **11**, and the sewage is passed through the rotating cylindrical screen and then transferred to a sewage storage tank **14** through the inner space of the cylindrical screen, and the food wastes drop out of the cylindrical screen without passing through the cylindrical screen and pile up on the entrance of the secondary treatment system.

The cylindrical screen was operated continuously at about 60 rpm. This separator allowed separation even at low speed unlike other high-speed separators, and allowed continuous separation without a clogging phenomenon. The water quality of the kitchen sewage which passed through the solid-liquid separator is given in **Table 5** below.

Example 5: Food waste COD removal efficiency of solid-liquid separator B

The kitchen sewage generated in the kitchen of one household reaches about 250 L per day. The kitchen sewage can be divided into particulate kitchen wastes passing through about 5 mm plastic mesh, and soluble kitchen wastes. Food wastes that are separated and collected from a kitchen are all particulates. The soluble COD and particulate COD of the kitchen sewage and food wastes generated in a restaurant inside KAIST, before and after grinding, are given in **Table 1** below.

Table 1: Soluble COD and particulate COD of kitchen sewage and food wastes before and after grinding.

		Total COD (mg/L)	Soluble COD (mg/L)	Particulate COD (mg/L)
Kitchen sewage		4950	2500	2450 (49.5%)
Kitchen sewage and food wastes (5 g/L)	Before grinding	5950	2450	3500 (58.8%)
	After grinding	5950	2400	3550 (59.6%)

In **Table 1**, the ratio of the particulate COD to soluble COD of kitchen sewage is about 50:50, 5 g/L of food wastes corresponds to 1 g/L as dry weight, and about 1,000 mg/L increase in COD can be expected. It can be found that there is no significant change in soluble COD, and food wastes mostly remain as particulates even after grinding.

COD removal rate was measured on a mixture of food wastes and kitchen sewage generated in the KAIST restaurant, using a rotating cylindrical screen unit and a sand-filled column. The results are given in **Table 2**. In this measurement, the rotating cylindrical screen had an inner cylinder with a diameter of about 15 cm, and an outer cylinder with a diameter of about 20 cm and a mesh size of about 0.5 cm, and was rotated at 60 rpm. The sand-filled column had a size of 8 cm x 3 cm x 40 cm, was filled with sand having a particle size of 2~5 mm. The flow rate of inflow water was 3 L/min.

Table 2: Results of measurement of COD removal rate.

Device	Classification		COD (mg/L)	COD removal rate (%)	Cumulative removal rate (%)
Rotational cylindrical screen	Inflow water	Total	13,857		
		Particulate	12,374		
	Outflow water	Total	6,000	56.7	56.7
		Particulate	5,225	60	
Sand-filled column	Inflow water	Total	6,000		
		Particulate	5,220		
	Outflow water	Total	2,600	56.7	81.2
		Particulate	1,825	65	86

Food wastes and kitchen sewage from a kitchen are mainly generated

during processes of preparing meals for breakfast, lunch and dinner and then washing the dishes after the meals. Also, it is considered that there is no generation of food wastes in general households from PM 8 to AM 6. Since several households of a group residential facility take meals at different times, there is high possibility for the generation times to have a very wide distribution.

For reference, the COD of 20 L kitchen sewage collected from one household in Taejeon, Korea, before and after cooking, is 1950 mg/L. When considering that the amount of kitchen sewage is about 250 L and combined with laundry sewage and bath sewage, this COD is reduced to less than 1000 mg/L. Adding food wastes thereto makes about 0.175 kg (0.25 kg x 0.2 x 3.5), and if it is divided by about 250 L of kitchen sewage and about 500 L of living sewage, the CODs of about 700 mg/L and about 350 mg/L, respectively, is added. Since the average COD of the living sewage discharged from households is about 250~1,000 mg/L, it can be found that the ratio of kitchen sewage COD to food waste COD is about 1:1.

Thus, it is reasonable that COD removal rate is based on daily total amount (integral removal rate) other than momentary differential removal rate. **Table 3** shows COD removal rates which were estimated when the particulate COD removal rate of the cylindrical screen-type solid-liquid separator B is assumed to be 60% and the particulate COD removal rate of the sand-filled column is assumed to be 65%, and introduced at (kitchen sewage COD)/(food waste COD) ratios of 500:500, 250:250, 250:500, 500:250, 500:1000, 1000:500, and 1000:1000, respectively.

Table 3: Results of estimation of COD removal rates.

Items	Unit	Classification	Test results						
Kitchen sewage COD	mg/L	S	250	125	125	250	250	500	500
		P	250	125	125	250	250	500	500
		T	500	250	250	500	500	1000	1000
Food waste COD	mg/L	S	0	0	0	0	0	0	0
		P	500	250	500	250	1000	500	1000
		T	500	250	500	250	1000	500	1000

Total COD	mg/L	S	250	125	125	250	250	500	500
		P	750	375	625	500	1250	1000	1500
		T	1000	500	750	750	1500	1500	2000
COD after passing through cylindrical rotating screen	mg/L	S	250	125	125	250	250	500	500
		P	300	150	250	200	500	400	600
		T	550	275	375	450	750	900	1100
	%	Removal rate	45	45	50	40	50	40	45
COD after passing through sand-filled column	mg/L	S	250	125	125	250	250	500	500
		P	105	53	88	70	175	140	210
		T	355	178	213	320	425	640	710
	%	Removal rate	35	35	43	29	43	29	35
Cumulative removal rate	%	Removal rate	65	65	72	57	72	57	65

In **Table 3**, S represents soluble food wastes, P represents particulate food wastes, and T represents the sum of S and P. As shown in **Table** 3, it can be found that the sewage separated by the solid-liquid separator B is maintained at water quality similar to that before introducing the food wastes.

Example 6: Biological treatment of food wastes

The food wastes ground in a kitchen are introduced into an anaerobic bioreactor through a solid-liquid separator B (Method A of **FIG. 1A** and **1B**). Before introducing the food wastes into the biological treatment system, it is preferable to separate sewage from the food wastes. Three methods including Methods A, B and C shown in **FIG. 2** can be applied. Namely, there can be used Methods A and C where food wastes and sewage are initially separated from each other by pipelines in a kitchen, and Method B where food wastes are separated from large amount of water. In the existing apartment buildings having no food waste pipeline, only Method B can be used. The sewage separated by the application of Method B is discharged to a drainpipe after it is subjected to filtration and other treatment processes, thereby maintaining water quality similar

to kitchen sewage before mixing with food wastes. The separated food wastes are automatically introduced into the biological treatment system shown in **FIG. 7**, which is a secondary treatment system. The process of introducing the food wastes into the biological treatment system is characterized by that a pump is not used.

For a 100-household apartment building, the reactor has a volume of about 5 m^3, and for a 200-household apartment building, the reactor has a volume of about 10 m^3. The methane gas generated from the reactors is 15 m^3/day and 30 m^3/day, respectively, 80% of which remains even after used to warm the respective reactors in the winter season. The water used to treat the food wastes is discharged as clear water having a COD of 50 mg/L and a turbidity of less than 130 NTU, such that it can be used as gray water after additional purification. The treatment of the food wastes is anaerobically performed so that it minimizes additional energy consumption and is so eco-friendly that there is no smell at a distance of 1 m from the reactor.

Example 7: Treatment of food wastes from group kitchen facilities

In the case of group feeding facilities, such as schools and troops, a generation site of food wastes is concentrated on one place. In most cases, the food wastes are contained in a basket with holes and separated from water. The food wastes are introduced into a grinder installed in a kitchen, added with some water, and transferred to an anaerobic treatment facility inside or outside the kitchen. If the food wastes are present in a mixture with kitchen sewage, chopsticks, plastics and yogurt bottles, etc., are separated by an automatic screen system, after which the food wastes are separated from the kitchen sewage by the solid-liquid separator A and then introduced into the grinder. The ground food wastes are transferred to the treatment facility through a transfer pipe, and then subjected to anaerobic treatment to give about 1 m^3 of biogas (methane content: 55~60% per kg of COD). If the number of persons supplied with food is about 1,000, the food waste of 40 kg (200 kg x 0.2) of dry weight can be obtained, and

the amount of biogas generated will be 40 m^3 (methane content: 55~60%). Heat capacity generated from the above methane gas remains about 80% even after used to maintain the treatment facility at 35 °C.

Example 8: Volume of anaerobic reactor for food waste treatment

The present invention considered the facts that the area for the food waste treatment system in residential facilities, such as apartment buildings, and group kitchen facilities, such as schools and troops, is limited, and food wastes from such facilities should be treated on-site in a sanitary manner. Facilities to which the present invention can be applied are those which are used by less than 1,000 persons and from which about 200 kg of food wastes are generated daily.

In the case of a 90-household apartment building, the amount of food wastes generated daily is about 87.5 kg, and a dry weight is about 17.5 kg, when assuming that the solid content of the food wastes is 20%. If the food wastes are anaerobically treated at 36°C, the reactor has a throughput of 1.6~7.9 kg/M^3·day (Chang, H.N. and Seo, J.H., Biochemical Engineering, p432, Academy Book, Co., 2001; and Park, S.C., Workshop materials of a Society of Bioenergy Technology Research, p21, 1999). If the food materials are aerobically treated, the reactor has a throughput of 3 kg/M^3·day (Park *et al.*, *Bioresource Tech.*, 73:21-27, 2000). If the reactor is operated at a high temperature of 55 °C, high energy is required but the speed of the treatment is about two times increased as compared to the case operated at 35°C (SEO, M.K. *et al.*, Unit Operations for Wastewater Treatment, SciTech, p572, 1998).

The volume of the reactor, which was calculated on the basis of the above data, is 2~9 m^3 for apartment buildings in Chungdam-dong, Kangnam-Ku, Seoul, Korea, since the daily throughput of the reactor is 2~8 kgVS/m^3. In the case of the restaurant in KAIST, the required volume is 5~20 m^3, when assuming that the dry weight of food wastes is 40 kg. This indicates that there is a space to place the reactor around the restaurants or apartment buildings.

Example 9: Comparison of convenience and energy consumption of the inventive method

The present invention is convenient that food wastes are not handled by hand in a kitchen where the food wastes are generated. Namely, the food wastes are ground three or four times a day immediately after their generation without storage, and then transferred. The food wastes separated by the solid-liquid separator are completely digested without leaving treated residues, and thus, the present invention is considered as a method capable of fundamentally solving the problems of food wastes in Korea.

The anaerobic treatment method employed in the present invention produces methane gas energy, whereas the method used in USA is an energy-consuming method where ground food wastes are transferred to a sewage treatment plant to aerobically treat them. Thus, the inventive method is considered to be more energy-saving and economic than the method used in USA. For example, when assuming that only 50% of 4,000,000 tons of food wastes generated in Korea are treated in sewage treatment plants, 1 kg of dry weight is 1 kg of BOD, and a power of 1 kwh is required to treat 1 kg of BOD, treating them by an aerobic method requires about 40 billion won (Korean money), whereas anaerobically treating the food wastes on-site allows the utilization of methane gas equivalent to about 96 billion won (SEO, M.K. *et al.*, Unit Operations for Wastewater Treatment, SciTech, p589, 1998).

The energy required in the inventive method is as follows. In the case of a 100-household apartment building, a grinder installed in each household generally has a capacity of 3/4 hp and is operated for about one minute per day, so that the energy required to operate the grinder is negligible. The solid-liquid separator B has a capacity of 1/2 hp and operated for about 8 hours per day, and the mixing pump of the anaerobic reactor has a capacity of 1/2 hp and is operated for about 4 hours per day, and thus, total power consumption is less than 5 kwh/day. Although the great amount of heat capacity is required to warm the anaerobic reactor and for heat loss, the anaerobic reactors for 100 households and 1000

households produce 82% and 87% surplus energies, respectively, even after used to warm the respective reactor in the season of spring and autumn. When comparing to current energy consumption reaching about 300~13,415 won per month/household according to a food waste treatment method, the inventive method requires an energy consumption of less than 150 won per month that is the lowest level (Park, S.N. *et al.*, The Proceedings of 2002 Autumn Scientific Research Symposium, Korea Society of Waste Management, p291~294).

While the present invention has been described in detail with reference to the specific features, it will be apparent to those skilled in the art that this description is only for a preferred embodiment and does not limit the scope of the present invention. Thus, the substantial scope of the present invention will be defined by the appended claims and equivalents thereof.

INDUSTRIAL APPLICABILITY

As described and proved above, the present invention provides the food waste treatment method having an effect that food wastes from large-scale residential facilities, such as an apartment buildings, large-scale kitchen facilities, such as universities and troops, or households, are treated in a sanitary and energy-saving manner without passing through human hands. The present invention is particularly advantageous that the space required for the on-site treatment system is small, an eco-friendly method, which does not generate noise and odor, is used, and the secondary treatment of residues is not required. Also, in a national point of view, whereas the treatment of food wastes together with sewage in a sewage treatment plant utilizes an aerobic method and thus requires high energy consumption, the on-site treatment utilizes an anaerobic method and thus is advantageous in terms of energy saving.

As a result, the food waste treatment method according to the present invention enjoys the convenience and advantages of the American-style disposer system in a kitchen, but has an advantage that it does not impose the burden of a

food waste treatment on the existing drainpipes or sewage treatment plants in Korean cities. Thus, the present invention is expected to be very useful to change the paradigm of food waste treatment.

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WHAT IS CLAIMED IS:

1. A method for the on-site treatment of food wastes from group residential facilities and group kitchen facilities, the method comprising the steps of:

(a) grinding food wastes by a grinder installed at the lower end of a kitchen sink;

(b) separating kitchen sewage from the ground food wastes by a solid-liquid separator A placed downstream of the grinder, the solid-liquid separator A having a structure where a food waste pipeline **5** and a sewage drainpipe **6** are connected to each other by a selection valve **4**, such that when the grinder **2** is not operated, kitchen sewage is transferred to the sewage drainpipe, and when the grinder is operated, the ground food wastes is transferred to a secondary treatment system together with a small amount of kitchen water through the food waste pipeline; and

(c) secondarily treating the ground food wastes in the secondary treatment system.

2. The method according to claim 1, further comprising the step of separating the kitchen sewage used in the food waste transfer, by a solid-liquid separator B of a cylindrical screen, flat screen or filter type, before transferring the food wastes separated by the solid-liquid separator A to the secondary treatment system.

3. A method for the on-site treatment of food wastes from group residential facilities or group kitchen facilities, the method comprising the steps of:

(a) grinding food wastes by a grinder installed at the lower end of a kitchen sink;

(b) transferring the ground food wastes to a solid-liquid separator B of a cylindrical screen, flat screen or filter type, using kitchen water;

(c) separating a large amount of sewage from the ground food wastes, using the solid-liquid separator B;

(d) transferring the separated sewage to a drainpipe, and transferring the ground food wastes to a secondary treatment system; and

(e) secondarily treating the ground food wastes in the secondary treatment system.

4. A method for the on-site treatment of food wastes from group residential facilities or group kitchen facilities, the method comprising the steps of:

(a) separately discharging food wastes and kitchen sewage, using a food waste pipeline separate from a drainpipe, in such a manner that the kitchen sewage is transferred to the drainpipe, and the food wastes are ground by a grinder installed at the lower end of a kitchen sink;

(b) transferring the ground food wastes to a solid-liquid separator B of a cylindrical screen, flat screen or filter type, using a small amount of the kitchen sewage;

(c) separating a mixture of kitchen sewage and ground food wastes discharged from households, into the kitchen sewage and the food wastes, using the solid-liquid separator B;

(d) transferring the separated kitchen sewage to a drainage and transferring the ground food wastes to a secondary treatment system; and

(e) secondarily treating the ground food wastes in the secondary treatment system.

5. The method according to claims 2, 3, or 4, wherein the cylindrical screen-type solid-liquid separator B comprises: a pipeline **3** into which the ground food wastes and the sewage are introduced; a cylindrical screen **11** consisting of a cylindrically rolled net with a 0.02~2 mm mesh size for separating the sewage from the ground food wastes; a motor **13** for rotating the cylindrical screen; a storage tank **14** for storing the separated sewage; a discharge valve **15** and a drainpipe **8** for discharging the sewage; and means **12** for transferring the food waste solids separated from the sewage by the cylindrical screen, into a secondary treatment

system **7**.

6. The method according to claims 1, 3 or 4, wherein the secondary treatment system comprises: a food waste inlet valve **12**; a cell recycle-type anaerobic reactor **19** filled with a porous ceramic carrier; a cell recycle-type aerobic reactor **20** filled with a porous ceramic carrier; a slurry circulation pump **21**; a unit **23** for injecting air into the aerobic reactor; a gas discharge pipe **24** for discharging methane gas generated by anaerobic treatment and carbon dioxide generated by aerobic treatment; a temperature control unit **22** for controlling the temperature of the treatment system using the generated methane gas; and a sewage discharge valve **15**.

7. A system for separating food wastes into sewage and solids, the system comprises: a pipeline **3** into which ground food wastes and sewage are introduced; a cylindrical screen **11** consisting of a cylindrically rolled net with a 0.02~2 mm mesh size for separating the sewage from the ground food wastes; a motor **13** for rotating the cylindrical screen; a storage tank **14** for storing the separated sewage; a discharge valve **15** and a drainpipe **8** for discharging the sewage; and means **12** for transferring the food waste solids separated from the sewage by the cylindrical screen, into a secondary treatment system **7**.