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A Study on Improvement of Distribution Facility in Wholesale Agricultural Products Market

Won-Mo Gal*, Ki-Tae Kwon**, Woo-Sik Lee***, Eun-Mee Choi****, Lee-Seung Kwon*****, Seung-Hwan Seong*, Woo-Taeg Kwon**

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Abstract

Purpose - The purpose of this study is to investigate the effect of gamma - irradiation on the effluent from food distribution in the large agricultural and marine products market. This study will contribute to the distribution process as well as the agricultural and fishery distribution facilities.

Research design, data, and methodology - In order to reduce the odor, the smell was examined in the anaerobic digestion process by irradiating gamma rays to the wastewater of mixed food discharged from a large restaurant. An odor determination panel list was constructed to determine if the odor was present in the air dilution drainage and the odor concentration was analyzed by instrumental analysis.

Results - It was confirmed that the sulfur content increased gradually from 3 months. Ammonia decreased from 33.57ppm at the initial measurement to 4.12 ppm at the end of the experiment. Methane production was highest at 100kGy when exposed to gamma rays of 0-200kGy at pH 12. In other words, it is considered that gamma irradiation doses are most effective at 100kGy and are suitable for large capacity wastewater treatment facilities in terms of economic feasibility.

Conclusions - In pre-treatment of compound food wastewater, gamma irradiation is most cost effective when examined at 100kGy. The economic efficiency of the pre-treatment method by gamma irradiation is much higher than the wastewater treatment in the large-scale agricultural and marine products distribution market.

Keywords: Wholesale Agricultural Products Market, Distribution Course, Improve Distribution Facilities, Economic Feasibility, Gamma Irradiation.

JEL Classifications: N55, O13, Q52, Q53, Q55.

1. Introduction

Since the liberalization of the retail industry law in 1996, Korea has been allowed to enter the market, and the traditional market has gradually lost its competitiveness. A policy was needed to revitalize traditional markets (Hong & Cho, 2014). Traditional markets, including the agricultural and marine products markets, have lost confidence in food and food for visitors to traditional markets due to the unhygienic environment and diverse odors of drainage, garbage disposal, food waste disposal sites, septic tanks and wastewater treatment plants. Therefore, there is a growing demand for improving the distribution structure, distribution process and

* First Author. Department of Health & Environment Safety, Eulji University, Korea.
Tel: +82-31-740-7230. E-mail: wongal@eulji.ac.kr
** Second Author. Department of Health & Environment Safety, Eulji University, Korea.
Tel: +82-31-740-7230. E-mail: kwun0745@hanmail.net
*** Third Author. Professor, Department of Chemical & Biological Engineering, Gachon University, Korea.
Tel: +82-31-750-5594, E-mail: leews@gachon.ac.kr
**** Fourth Author. Professor, Department of Health Care Management, Catholic Kwandong University, Korea.
Tel: +82-33-649-7583. E-mail: smart609@cku.ac.kr
***** Fifth Author. Professor, Department of Health Care Management, Catholic Kwandong University, Korea.
Tel: +82-33-649-7589. E-mail: leokwon1@cku.ac.kr
* Sixth Author, Department of Health & Environment Safety, Eulji University, Korea.
Tel: +82-31-740-7230. E-mail: satokei82@naver.com
** Corresponding Author. Professor, Department of Health & Environment Safety, Eulji University, Korea.
Tel: +82-31-740-7145. E-mail: awtkw@eulji.ac.kr

distribution facilities in the market (Park, 2005).

Although there are some differences according to the characteristics of the traditional market, the odor is mainly generated from the vegetable waste from the screening process and the food waste disused from the restaurant. Especially, the food waste contains a large amount of water and is easily decayed (Kwon, 2015). The malodorous component contains a complex active ingredient and mainly contains various components such as ammonia, trimethylamine, hydrogen sulfide, methyl disulfide, ethanol, n-butyl aldehyde, and valeraldehyde (Oh et al., 2011). This complex active ingredient contains a much wider variety of food wastes, especially from large restaurants than from small to medium sized restaurants.

Since odor is not a single component, depending on the degree of human sensation, the sensitivity of a sensitive or dull person may be 10 times or more different depending on the odor substance at the minimum sensory concentration (Threshold). Therefore, there is a limit to reduce the odor in the traditional market (NIES, 2003). In addition, the offensive discomfort of the odor is difficult to be quantified by a certain standard or measurement method, and the results are necessarily proportional to the concentrations and intensities of the substances due to seasonal, weather conditions, location, time. Therefore it is difficult to know the change of odor accurately (Kim, 2010). In order to fundamentally improve the environment of traditional markets, it is important to treat food waste in an environmentally friendly manner. This can be seen as an improvement in the distribution structure or a change in the distribution method.

Generally, the treatment of food wastes occurs in the pretreatment process that occurs before the fermentation process, although the odor concentration is high in the fermentation process. Most of these odorous substances are water-soluble, and therefore they are very soluble in water (MENIER, 2015).

In this study, the anaerobic digestion tank was fabricated on Lab scale and the amount of methane and carbon dioxide produced after gamma-ray irradiation on the wastewater of complex food was measured. Finally, the stabilized anaerobic digestion process was operated to reduce odor by analyzing the characteristics of organic matter removal efficiency and odor behavior.

In conclusion, this study aims at improving food distribution structure, distribution process and distribution facilities through approaching environmentally friendly and economical way of food waste from agricultural and marine products distribution market.

2. Theoretical Background

Food wastes Wastewater is a water pollutant generated in food wastes treatment process. It contains higher concentration of organic components (oil, fat, etc.) than ordinary sewage, and salt and substances which are difficult to decompose. Since the waste wastewater treatment of food wastes includes the degradation of oil, salt and organic materials, the existing wastewater treatment methods are low efficiency, inhibition of microbial activity, flocculation of oil during aeration during the aeration process, odor generation, and so on. Therefore, the anaerobic digestion process was introduced as the most suitable method for treatment of organic matter with high concentration while eliminating these problems.

Most of the gas obtained as a by-product in the anaerobic digestion process is composed of methane and carbon dioxide, and other constituents include nitrogen, oxygen, and sulfur. Among them, nitrogen and sulfur are well known as odor substances that generate odor.

2.1. Characteristics of Composite Waste Water

Food wastes contain high concentrations of solid organic matter and contain low pH and high salinity. Food waste has a solid concentration of about 20% and contains many other foreign substances. The degradable VS/TS in the total anaerobic digestion process (A. D. process, anaerobic digestion process) was about 0.7~0.8. About 20% of total solids are classified as non-decomposable ash (FS, fixed solid). That is, it is most important that the foreign substances and the impurities are separated or pulverized from the treatment facilities to increase the anaerobic digestion efficiency.

When the average suspended solids (VSS) of the organic material is more than 64%, it is difficult to convert the methanogenic microorganisms into usable form due to the low molecular saccharides, amino acids and fatty acids generated in the anaerobic digestion process. Therefore, in general, the waste water desalination solution is mixed with sewage sludge rather than treated alone.

According to Jang et al. (2016), VS removal efficiency was 43.3% when treated with sewage sludge alone, but was 58.2% at the combined treatment of 75:25 and 50:50 (sewage sludge: food waste wastewater), and 66.1%, respectively. Methane production also increased in the range of 30:70 ~ 50: 50 (sewage sludge: food waste wastewater).

However, when more food waste was added, methane production decreased. According to the results of Sung et al. (2002), the methane production rate tended to increase at the combined ratio of 100:0 ~ 60:40, but it decreased when the food waste was added.

2.2 Odor Characteristics of Compound Waste Water

In the anaerobic digestion tank, nitrogen compounds (ammonia, trimethylamine, etc.), sulfur compounds (hydrogen sulfide, methyl mercaptan, dimethyl sulfide etc.), organic acids (butyric acid, Glacial acetic acid, etc.).

Since these odorous substances affect the surrounding environment, it is necessary to make the facilities and equipment that are brought into a sealed structure and ventilation possible if possible.

2.3. The need for odor management

It is not known exactly how much of the odorous substance, hydrogen sulfide, mercaptans, amines, and other irritating gaseous odorous substances have in the human body. However, when people are exposed to odor, it does not cause illness or disease immediately. However, long-term exposure may cause headache, dyspnea, vomiting, nausea, stimulation of allergic reactions and sensory stimuli, irritability, anxiety and discomfort, It is known to cause mental stress.

Domestic emission standards for odor are 4,300 cases in 2005, 7,300 cases in 2010, and 10,000 cases in 2012 due to various reasons and increase in national income, and the number of complaints is rapidly increasing to about 13,000 in 2015.

2.4. Odor reduction technology

In order to eliminate or reduce the odor, it is important to select the most appropriate method for removing the odor by examining the target reference concentration and composition of the odor component in advance. There are physical, chemical and biological methods for odor prevention, and the most commonly used method is a chemical solution cleaning method in which a deodorization is carried out by an irreversible chemical reaction between the odor component and the main component of the chemical solution.

However, there are difficulties such as a large amount of wastewater, an increase in the cost of medicine, and a problem of freezing. Therefore, it is necessary to measure and model the odor when designing the preventive facility, and it is important to install the deodorizing method suitable for the odor component.

2.5. Chemical effects of gamma rays

A gamma ray is an electromagnetic wave such as light in the flow of energy itself. When an electron beam or a gamma ray having this energy is collided with a substance, an ionization and an excited state are generated in the substance due to the interaction with electrons and substances. When we look at the mechanism of pollutants treatment, when gamma rays are radiated to a molecule or mixture of compounds, the mixture absorbs energy, creating excited molecules, free radicals, from the interaction of these ion mixtures.

Accelerated electrons are generated by electronically excited states and free radicals when irradiated in water, and the reaction is dependent on pH, impurities, temperature, and OH radicals. H radicals and hydrated electrons (e-aq, Aqueous electron) are formed as a result of radiation decomposition of water. Based on this, the total equation for the radiation decomposition of water can be summarized as follows.

$$H2O \rightarrow e\text{-}aq + .H + .OH+ + H2+ + H2O2+ + H2O-$$

The reaction in the organic solute is generally an oxidation/reduction reaction, and the primary products obtained from the reaction of the primary radiolytic species with the dissolved solute can undergo various reactions depending on the type of the system being examined. This reaction can be different in the presence and absence of oxygen, and can be decomposed by oxidizing or reducing organic contaminants. Among the products, the most reactive is OH (hydroxyl radical), which reacts with eaq- (Aqueous electron) and H (hydrogen radical), which are reducing agents.

2.6. Anaerobic digestion facility

Anaerobic digestion is a technology applied to stabilize organic wastes in the absence of dissolved oxygen and decompose them into organic or inert minerals to obtain methane and carbon dioxide as by-products, and to reduce sludge in the sewage treatment and to the environment. In recent years, anaerobic digestion has been applied not only to energy recovery of organic wastes such as manure, wastewater, wastewater, livestock wastewater and municipal wastes, but also to change of food wastes and distribution structures in order to reduce greenhouse gases and energy.

In anaerobic digestion design, it is necessary to consider that the pathogen and its medium are eradicated in the process of microbial action, and at the same time, more than half of organic matter in sludge is liquefied and gasified and odor is generated. The sludge digestion process is divided into high temperature digestion (50~55℃) and middle temperature digestion (30~35℃) with digestion temperature (about 40℃) as the boundary.

Food wastes are separated from solid and water by pre-treatment such as screening → crushing → dehydration, and the solid material is recycled as compost and feed, and water is discharged as waste water. Some of the discharged wastewater is transported to a bio-gasification facility or treated as sewage treatment.

The anaerobic digestion facility is characterized by the fact that the entire amount of digestive effluent is generated as wastewater. Most of the facilities are located in the vicinity of the sewage end treatment plant, which is a large-scale environmental foundation, and can be linked to each other. As of 2015, the operating rate of anaerobic digestion facilities is 75%, which is lower than the combined treatment (NSBPD, 2012). The core technology of the anaerobic digester is evaluated by the economic feasibility of the methane production and the processing cost of the operating costs such as electricity and heat according to the generation consumption to operate the anaerobic digester. In order to improve the economical feasibility of the bio-gasification facility, it is necessary to install it in a sewage disposal plant or a similar wastewater treatment plant, or to associate digestion desorption liquid and digested sludge. It is necessary to improve the pre-treatment facilities and reduce the construction cost and operating cost by reducing the odor and enlarging the scale. Domestic organic wastes and anaerobic digestion of wastewater began to be developed at the government level in accordance with the Alternative Energy Development and Utilization Promotion Act since 1988. This research mainly focused on high-efficiency anaerobic processes such as up-flow and anaerobic sludge blanket (UASB) reactors, mainly used in university wastewater treatment such as starch wastewater and beer wastewater.

3. Food Processing Wastewater Treatment

The nature and volume of wastewater from food waste depends on the size of the restaurant or city. The wastewater properties of the food processing restaurant emit a particularly odor of acidification as well as high BOD, SS and oil concentrations. Nearly all wastewater treatment methods are unique. However, there are some common patterns that follow the wastewater treatment design.

1. Food wastewater flows from a production site to a sort of collection basin. From there it is screened to remove bold or heavy solids that can damage the process pump. Proper screening helps reduce chemical consumption, protects process pumps, and lowers operating costs.
2. After passing through the screening equipment, wastewater is collected and blended together to form a homogeneous solution. This is called Equalization.
3. From the EQ tank, wastewater is pumped into a flocculator for chemical treatment. Dosing pumps meter pH reagents, coagulants, and flocculants into the flocculator to help agglomerate solid materials into large, floatable flocs.
4. Water then flows into a DAF unit where the physical separation takes place. Sometimes the DAF process designer opts for a plate pack DAF system and other times for an open tank DAF unit. When each DAF system is used is an interesting discussion.
5. Separated solids flow out of the DAF system as sludge. Depending on the nature of the removed solids, various sludge management options are considered.
6. Clarified water flows out of the DAF unit onto further processing or for discharge.

Countries make a lot of effort to energize these food waste wastewater. In particular, many countries in Southeast Asia are investing heavily in food waste energy.

The Asian renewable energy market has grown by an average of 18% since 2009, making strategic importance to the Asian market increasing (Kim et al., 2010). Southeast Asia has abundant bioenergy resources and is a strategic location on the global bio-weight energy map. Southeast Asian countries have enormous bioenergy potential because they are abundant in various forms of bioenergy such as agricultural residues, wastewater, livestock wastes, and urban trash. In relation to the wastewater, although Southeast Asian countries have been driving economic growth for the past decade, at the same time, lack of sanitation facilities and inadequate industrial wastewater treatment caused high levels of contamination in many areas of the region. Therefore, the development of high efficiency wastewater treatment facilities in Southeast Asia not only provides a sanitary and safe environment, but also can contribute to the renewable energy industry.

Contaminated wastewater from textile dyeing companies, petrochemical processes, paper mills, sanitary landfill leachates, explosives and municipal sewage treatment plants occurs mainly in industrial complexes. The polluted wastewater generated in Korea is summarized as follows in <Table 1>.

<Table 1> Wastewater investigated at Korea (Behera et al., 2011)

Wastewater(from)	Purpose of Investigation	Results
Textile dyeing companies	Removal of color and organic impurities	Industrial plant constructed Improved removal efficiency
Papermill	Decrease in COD, color Increase in re-use rate	Reduction in COD, color Commercial plant designed
Leachate from landfill	Removal of organic pollutants	Bio-treatment efficiency improved
Heavy metals	Decrease in the contents in water	Removal of Cd(II), Pb(II), Hg(II), Cr(VI)
Power plant clean-up	Decrease in the contents of organic acid in water	Decrease in the contents of organic pollutants
Explosive production	Decrease in Color, COD, BOD, T-N for re-use	Decrease in COD, T-N Re-use for production

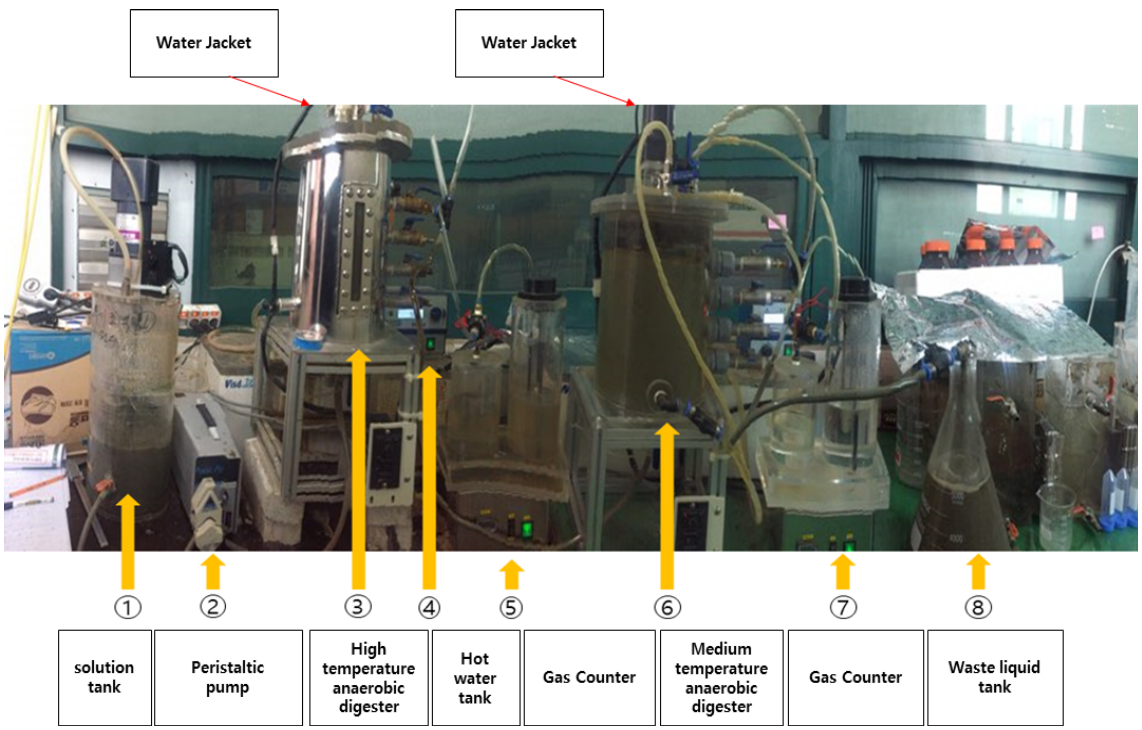
Ultimately, introducing technologies and methods to reuse polluted wastewater into industrial and agricultural fields means not only solving environmental problems, but also changing the structure and method of distribution of food.

4. Methodology

4.1. Anaerobic Digester Specification

<Table 2> shows that the structure of the anaerobic digestion tank is a 5L volume scale digestion tank that can be varied based on the main design of the digestion process. <Figure 1>. Especially, the high temperature anaerobic digestion tank was made of stainless steel in consideration of the reactivity of experimental wastewater and the mesophilic anaerobic digestion tank was made of acrylic material.

The anaerobic digester, which operates in a heterogeneous system consisting of three stages of solid (sludge) - liquid (wastewater) - gas (methane), adopts the upflow method with excellent stirring ability because stirring process is necessary for homogenization. Such an agitated environment constitutes a suitable environment for microbial growth and proliferation (Kim, 2002). The inlet and outlet of the experimental wastewater were provided with a valve at the bottom to collect the sample, and the generated gas was collected and discharged through the upper valve. Among the important factors affecting the microbial growth, rapid temperature change can cause serious problems in the growth and proliferation of microorganisms. Therefore, the temperature of the digester can be controlled by using a water jacket by a water jacket having a small temperature change and a quick return speed respectively (Kim et al., 2002). Stabilization test was performed to establish the initial operation condition for stabilization of anaerobic digestion tank. First, a hydraulic pump test was performed on the anaerobic digestion tank, and the gas and liquid were sealed (Ahn et al., 2003).



<Figure 1> Pre-treatment and anaerobic digester unit configuration

<Table 2> Anaerobic digestion constructed

Design criteria	Specifications		Etc.
	High temperature anaerobic digester	Mesophilic temperature anaerobic digester	
Digestion temperature	55℃±1	35℃±1	Water jacket
material	SUS	Acryl	
Sample inlet pump	450 mL/day		Metering Pump
agitator	Upflow agitation		
HRT	10 Day		
volume	5 L		

4.2. Selection of Experimental Wastewater

The sewage sludge was collected from the sewage sludge treatment plant in the city of D, and the sewage sludge was mixed with the ratio of the sewage sludge of 2 and the ratio of the food waste water of 8. <Table 3> shows the measured characteristics of the wastewater, sewage sludge and wastewater treated wastewater using a standard mesh (1mm sieve and 10μm) to remove impurities from the wastewater.

<Table 3> Properties of waste water used experimental

Division	Sewage sludge (Average)	Food wastewater (Average)	Composite food wastewater (Average)
pH	7.1	3.4	6.6
DO(mg/L)	0.3	0.4	0.3
TCOD(mg/L)	25,204	518,957	123,954
SCOD(mg/L)	9,894	335,028	74,920
TS(mg/L)	165,650	21,240	136,768
VS(mg/L)	13,225	12,200	12,299
TSS(mg/L)	32,400	211,500	69,397
VSS(mg/L)	21,950	208,950	59,350
T-N(mg/L)	750	803	762
NH3-N(mg/L)	99.2	259.8	131.3
NO3-N(mg/L)	5.7	311.5	66.8
T-P(mg/L)	724.1	917.6	762.8
Carbohydrates(mg/L)	1,103.9	34,473.7	7,789
Proteins(mg/L)	703.9	34,157.9	7,395
Soluble proteins(mg/L)	427.6	473.7	438
Lipids(mg/L)	2,056.0	-	1,655

4.3. Gamma irradiation dose

In order to evaluate the methane (CH4) production and the solubilization of the wastewater pre-treated by gamma irradiation, gamma radiation was generated at 1.47 × 10 17 Bq (397,949 Ci) using a high-level Co60 source (MDS Nordion, Canada) methane potential test. At this time, dose was set to 0, 50, 100, and 200kGy, respectively, and the doses obtained by irradiating the composite wastewater for 8 hours were selected and tested.

<Figure 2> Gamma irradiation device

4.4. Analysis of gas and odor substances in anaerobic digester

4.4.1. Gas production

The change of daily gas production from anaerobic distion was confirmed. The collected gas was collected at the upper part of the hot anaerobic digestion tank and the mesophilic anaerobic digestion tank, and the collected gas was collected and analyzed by GC / TCD and GC / FPD.

4.4.2. Air dilution sensory method

Sampling was done by using a suction box with a closed structure and a filter installed at the inlet of the sampling pipe so that dust was removed when sampling (Kim et al., 2011). The sample dilution bag and the odorless pouch were made of polytetrafluoroethylene (PTFE), which was filled with a high purity nitrogen gas at least once before use, and 20L was washed and exhausted.

Since odor test of complex odor is a sensory test method influenced by the panel composition, the judge made a maximum restraint of strong cosmetic and odorous substances on the day of judgment, fully explained the order of judgment test, A total of 5 men and 22 women and 35 men were selected. The test is started from the concentration that can easily receive the odor to be evaluated. If the odor is detected by the judgment staff, the dilution magnification is increased by 3 times. If the odor is not detected, the odor is judged from 300 times.

For the samples collected from the hot anaerobic digestion tank, the judging staff wearing sensory test masks were allowed to smell for 2 to 3 seconds each while pressing the sample dilution bag and the odorless bag by hand, and to identify the diluted air bags which were increased step by step. After each step of the test, the patient was breathed in fresh air for at least 5 minutes before the next step. In the calculation process, the maximum and minimum values were excluded based on the results of the five persons' judgment, and the geometric mean of the remaining three persons was determined to be the dilution multiple of the total odor detection limit.

4.5. Ammonia

For the analysis of ammonia concentration from the anaerobic digestion tank, 0.5% boric acid absorbent was placed in the absorption bottle and absorbed at 10L / min (APPT, 2017). After the aspiration of the sample is completed, the solution in the entire absorption bottle is transferred to a beaker. The sampling tube and the absorption bottle are rinsed with an absorbing solution and added to a solution in a beaker, and then transferred to a 250ml measuring flask. Was used as a sample solution for analysis.

Add 5mL of sodium phenol pentacyano-silicate (III) solution to 10mL of sample solution for analysis and ammonia standard solution, shake well, mix 5mL of sodium hypochlorite solution, add 1 After incubation, the absorbance at 640nm was measured (Shimadzu UV 1280) and the concentration was calculated by the equation. For the blank test solution, 10mL of the sample solution (absorbing solution) was used by operating in the same manner as the sample solution for analysis.

4.6. Sulfur compound

In order to measure the odor concentration generated in the anaerobic digestion tank, a sample was collected by a suction box method with a Tedlar bag inside (APPTM, 2017a). At this time, the suction box was made to have a sealable structure, and the suction pump was operated at a rate of 1L / min. The Tedlar bag used was made of polyvinyl fluoride film. It was cleaned by sucking and exhausting with high purity nitrogen gas more than twice before use, and the filter was installed at the inlet of the sampling pipe to remove the dust and 3L was collected.

The samples were stored in the dark for direct sunlight and analyzed on the day of harvesting using the GC / FPD (HP 6890) method using an electric cooling low-temperature concentrator-capillary gas chromatograph (GC / FPD)

The dilution gas for the calibration curve is composed of a standard gas and dilution gas (nitrogen gas) connected in parallel, a structure in which the respective gases are combined, and a flow control device (MFC: mass flow controller) A dilution device was used.

<Table 4> Conditions of GC/FPD for analysis sulfur

Analytical instrument	Component	Analysis condition
Thermal desorber	cold trap	Carbopack B/Silica gel Filled quartz tube
	condition	concentration–30°C, Desorption 250°C, 5 min
GC/FPD	column	DB 5(60 mm × 0.25 mm × 1.0 ㎛)
	carrier gas	N2
	Inj. temp.	200°C
	Oven temp.	50°C(5min) → 10°C/min → 200°C(5 min)
	Det. temp	220°C
	Flow rate	2.0 mL/min

4.7. Acetaldehyde

A sample of acetaldehyde was sampled using an ozone scrubber (1.0cm ID × 4cm (L), Supelco Inc. USA) filled with potassium iodide (KI) crystals in a DNPH cartridge (LpDNPH S10L cartridges, Supelco Inc. USA) were connected to the front part to collect samples (MP-Σ100H, SIBATA) (APPTM, 2017b). The samples were wrapped in aluminum foil, sealed in a zipper bag that can be blocked from outside air, and stored at 4°C or lower until they were extracted with a solvent. 5ml of acetonitrile is passed through the cartridges from which the sample is collected, and the extracted solution is passed through a 5ml vial and finally added with acetonitrile to adjust the volume to 5ml. <Table 5> shows the analytical conditions for high performance liquid chromatography.

At this time, DNPH-derivatized aldehydes were used as a reference material to prepare a calibration curve by diluting with acetonitrile at five different concentrations each as a standard substance dissolved in.

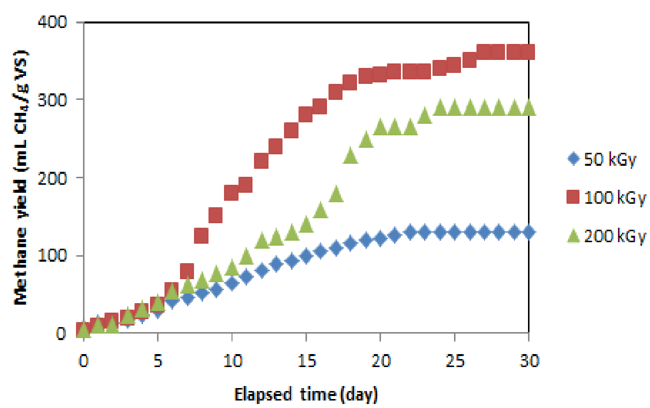
<Table 5> Conditions of analysis HPLC

Column	C18(4.6 mm × 250 mm)
Mobile phase	60% CH3CN / 40% H2O(V/V%)
Flow rate	1.0 mL/min
Inj. vol.	25 μL
Detector(wavelength)	UV(360 nm)

5. Results

5.1. BMP test

As a result of irradiating the sample with gamma irradiation to the compound wastewater and performing BMP test, <Figure 3>, it was 366mL · CH4/g · VS when irradiated with 100kGy of gamma ray. At 0kGy, methane did not occur during the BMP test.



<Figure 3> Methane production by gamma irradiation

5.2. Gas production of anaerobic digester

The amount of gas generated in anaerobic digester was about 600 ~ 4,500mL / day according to the change of daily gas production using anaerobic digester. In the stabilization step, the yield was about 500mL / day per kg CODMn / day at about 600mL / day. It was confirmed that the load ratio change and the gas production amount according to the impact load increase up to about 2,000mL / day per day.

In the mesophilic anaerobic digestion tank, the amount of gas generated at 100 to 500mL / day decreased slightly due to the influx of the sample which can use many microorganisms in the high temperature anaerobic digestion tank.

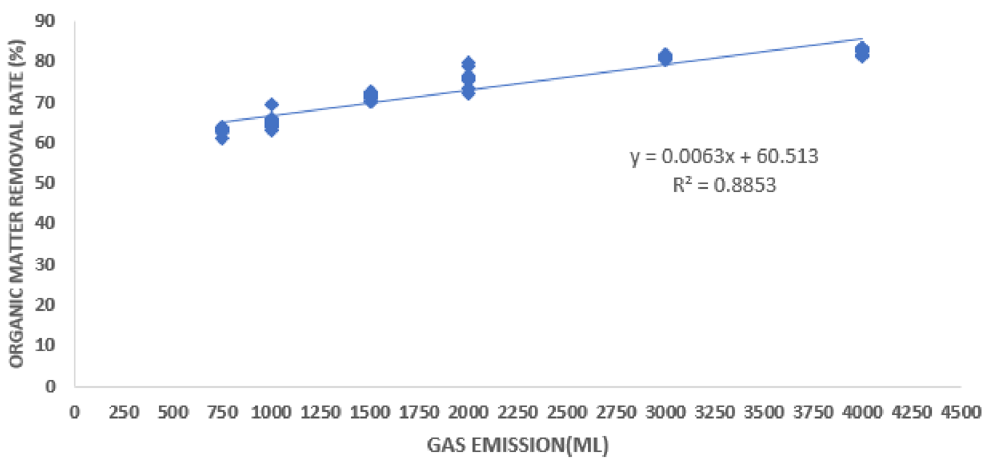
The organic matter removed by anaerobic digestion is discharged in the form of gas, and the amount of organic matter removed is proportional to the amount of generated gas. Therefore, the correlation between organic removal efficiency and gas production was analyzed.

In the high temperature anaerobic digester, gas production was increased in proportion to the organic matter removal rate as shown in <Figure 4>. On the other hand, in the mesophilic anaerobic digester, the organic removal efficiency is shown in <Figure 5>, which shows that the gas production is not directly proportional.

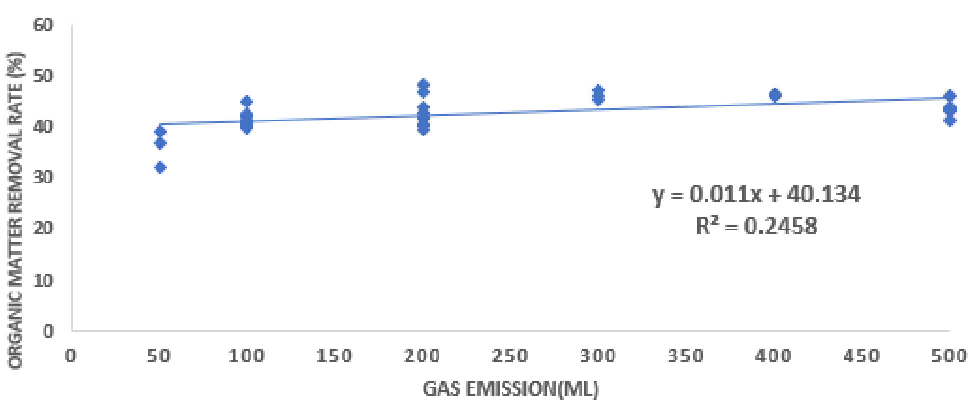
This is thought to be the result of adsorption and redistribution in addition to biomass organic matter removed from the hot anaerobic digester. The concentration of organic matter in the sludge entering the mesophilic anaerobic digester is not constant.

5.3. Composition of generated gas

The methane and carbon dioxide composition ratio and hydrogen sulfide in the high temperature anaerobic digester and the mesophilic anaerobic digester were 42.5% methane and 35% carbon dioxide, respectively, as shown in <Table 6>. In the mesophilic anaerobic digestion tank, the methane content was about 16.5% and the carbon dioxide content was about 56%. The sulfide content in the anaerobic digestion tank could be converted to hydrogen sulfide in the anaerobic digestion tank. As a result, it was 5.6 ppm in the hot anaerobic digestion tank and 2.8ppm . In the anaerobic digestion process, the composition ratio of gas was relatively constant regardless of the amount of gas production.



<Figure 4> Gas generation rate in high temperature anaerobic digester.



<Figure 5> Gas Generation rate in mesophilic temperature anaerobic digester.

<Table 6> Composition of gas produced in Thermo and Meso

Sample	CH4(%)	CO2 (%)	H2S(ppm)	Balance %)
Thermo	42.5 ± 3.2	34.6 ± 5.6	5.6 ± 1.2	10.4
Meso	16.5 ± 2.8	56 ± 1.5	2.8 ± 1.5	28.1

5.4. Odor measurement results

5.4.1. Results of air dilution sensory measurement

In the case of the air dilution sensory method, the composite wastewater treated with 0 kGy and 100kGy gamma rays was used for the hot anaerobic digestion tank. The results are shown in <Table 7>. The odor of the composite wastewater was 0 kGy compared to the 100kGy of composite wastewater. The odor of the wastewater was 10 times higher than that of the composite wastewater. As of October 10, the figure was the highest at 6.92 times. This means that the anaerobic digestion did not proceed because the hydrolysis by the organic fraction was not proceeded at 0 kGy and the methane production was not observed. In addition, odor was high even in a short stay for 10 days in a hot anaerobic digestion tank. In the case of air dilution sensory drainage, it was at least 44,814 times and a maximum of 100,000 times. Actual gamma irradiation promoted the hydrolysis by the decomposable substance, which not only destroys the cell wall but also reduces the odor, which can help to methane production and microorganism growth.

5.4.2. Ammonia measurement results

In order to analyze ammonia nitrogen by indophenol method, 0 kGy and 100 kGy were irradiated to analyze degradation substrate and characteristics of composite wastewater by gamma irradiation.

As a result, Fig. 6, the initial ammonia was 46.9 ppm in the case of 0 kGy, but it was 38.4 ppm in about 3 months. The average concentration was 35.82 ppm. The 100 kGy irradiated complex wastewater was identified at 33.3 ppm at the initial measurement, but then gradually decreased to 1.45 ppm. The average concentration was 12.79 ppm. It is considered that ammonia is reduced in the product gas composition in the anaerobic digestion tank by preventing the formation of ammonia due to carbon shortage by making the environment suitable for the production of methanogenic microorganism by balancing carbon and nitrogen in the decomposition substrate.

5.4.3. Hydrogen sulfide measurement results

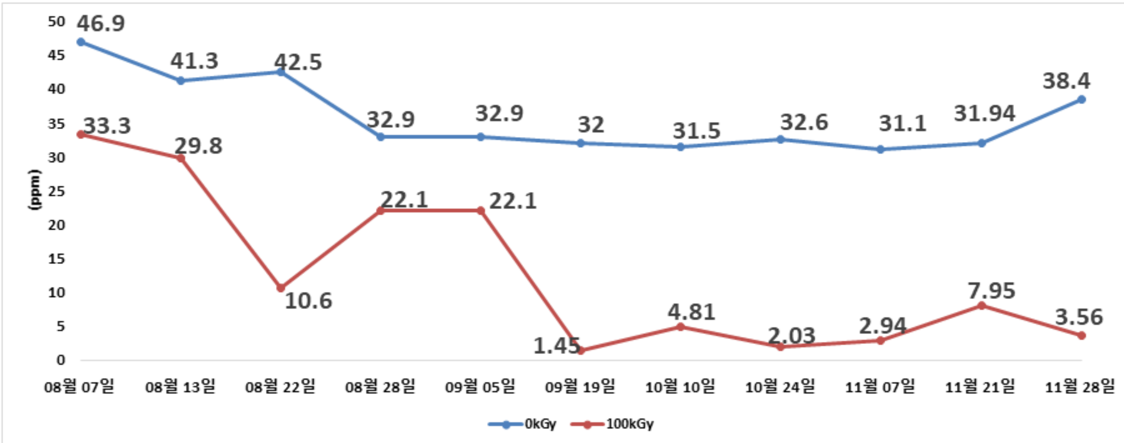
When sulfur contained in the wastewater is contained, it is present in the form of H2S, HS-, S-2 in the liquid phase, and is generated as hydrogen sulfide in the biogas.

In this study, the measurement was carried out using the GC / FPD method. <Figure 7>. The measured rate of change by 0 kGy ranged from about 14 to 20 ppm, while for composite wastewater irradiated with 100 kGy it ranged from 0 to 6 ppm. As a result of the measurement, it was confirmed that the gamma ray irradiation improves the solubility efficiency of the sludge to reduce the concentration of sulfur, but it was confirmed that the concentration of hydrogen sulfide gradually increased from November. It is considered that there is a period of about 3 months for the gamma irradiation sample to affect the dissolution rate of sulfur.

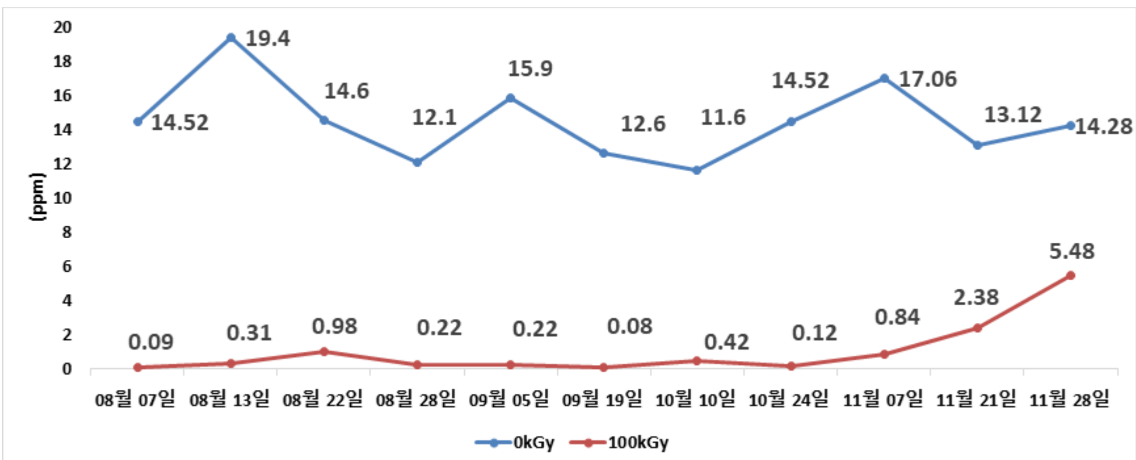
<Table 7> Results of Complex odor (0 kGy and 100 kGy)

Unit: Dilution factor

Division	Judge	Date									
		8/7	8/22	8/28	9/5	9/19	10/10	10/24	11/07	11/21	11/28
High temperature Digester (100 kGy)	A	30,000	100,000	100,000	30,000	30,000	10,000	10,000	30,000	10,000	30,000
	B	10,000	30,000	30,000	30,000	30,000	100,000	30,000	10,000	10,000	30,000
	C	10,000	30,000	30,000	10,000	10,000	30,000	30,000	10,000	10,000	30,000
	D	10,000	10,000	30,000	30,000	30,000	30,000	10,000	10,000	100,000	10,000
	E	30,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	30,000	30,000
Air dilution Sensual drainage		14,422	20,800	30,000	20,800	14,422	14,422	14,422	10,000	10,000	9,655
High temperature Digester (0 kGy)	A	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
	B	100,000	100,000	100,000	100,000	30,000	30,000	30,000	100,000	100,000	300,000
	C	30,000	30,000	30,000	30,000	100,000	100,000	100,000	100,000	30,000	100,000
	D	30,000	30,000	300,000	100,000	30,000	100,000	30,000	30,000	30,000	30,000
	E	30,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Air dilution Sensual drainage		44,814	66,943	144,225	100,000	66,943	100,000	144,225	100,000	144,225	144,225



<Figure 6> Concentration of ammonia



<Figure 7> Concentration of hydrogen sulfide

5.4.4. Methyl mercaptan measurement result

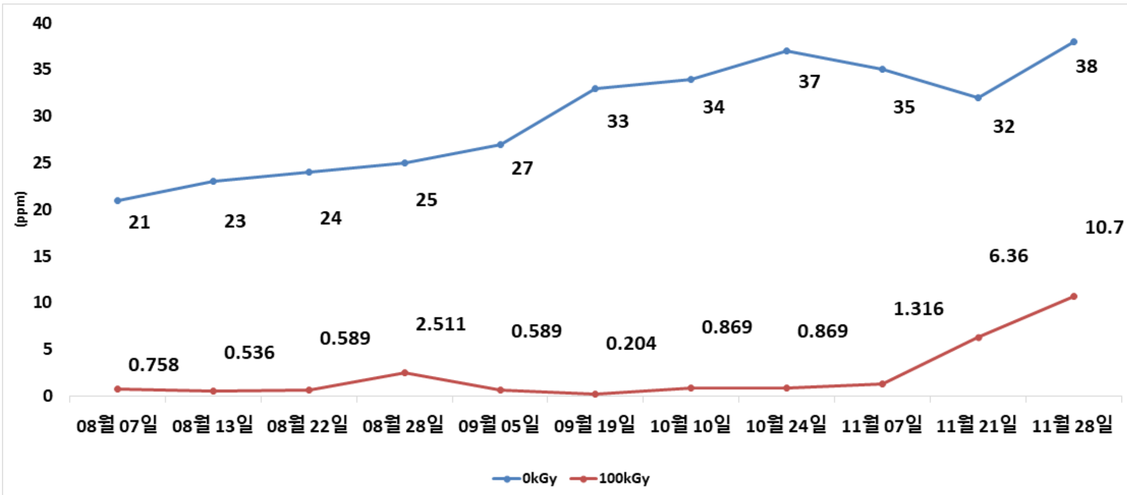
In the high temperature anaerobic digester at 0 kGy, Fig. 8, the average concentration of methyl mercaptan was 29.9 ppm, and the maximum concentration was about 35 ppm in about 3 months. Comparing this result with the exposure limit criteria indicates that the recommended exposure limit in all conditions exceeds 0.5 ppm. This concentration was about 5,980% of the average concentration and the maximum concentration of about 7,000% at 0.5 ppm of the time weighted average exposure standard (TWA) during the working day. This concentration was significantly exceeded compared to the reference value of 0.004 ppm and the minimum detection concentration of 0.0001 ppm.

As a result, the average concentration of methyl mercaptan in the high temperature anaerobic digestion tank was 2.3 ppm, and the maximum concentration in the range of about 3 months was 10.7 ppm. The results of 100 kGy were compared with the limit of exposure limit. In addition, the time-weighted average exposure standard (TWA) during 1-day work time was about 460% of the average concentration and 0.5% of the maximum concentration, and the maximum concentration was about 2,140%, which exceeded the reference value of 0.004 ppm and the minimum detection concentration of 0.0001 ppm respectively (MMMSDS, 2016).

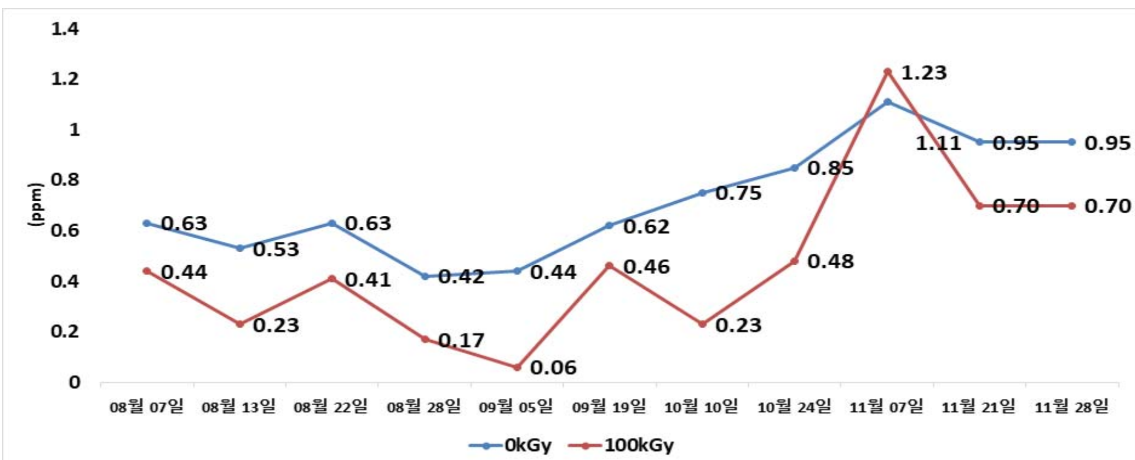
Methyl mercaptan may be partly remaining, so to prevent ventilation in the workplace and external leaks, we recommend that you seal all processes and install hoods for proper ventilation in the process of leaching leachate with the maximum concentration. It will be necessary.

5.4.5. Acetaldehyde

In the anaerobic digester, <Figure 9> showed 0.63 ppm at 0 kGy irradiation and increased up to 1.11 ppm (mean 0.72 ppm). The minimum detectable concentration of acetaldehyde is 0.0015 ppm and can exceed the emission limit of 0.05 ppm.



<Figure 8> Concentration of methyl mercaptan



<Figure 9> Concentration of Acetaldehyde

At 100 kGy irradiation, it was 0.44 ppm, but gradually increased to 1.23 ppm (mean 0.46 ppm). This is because the complex binding of carbohydrates, proteins and fats as initiators in the hydrolysis step in the anaerobic digestion process to the methane-producing microorganisms that consume hydrogen by acid-producing bacteria (hydrogen-forming bacteria) In the process of transformation, bacteria release enzymes that degrade substances biochemically. In this process, the intermediate product is responsible for decomposing monosaccharide fatty acids (acetic acid, propionic acid, butyric acid), carbon dioxide and hydrogen caused by bacteria during the so-called acid production process. It is believed that the result was the production of acetic acid under the influence of hydrogen and the production of acetaldehyde series.

6. Conclusion

As a result of BMP test by irradiating gamma ray to the compound wastewater, it was 366mL · CH4 / g · VS when the gamma ray was irradiated at 100 kGy. At 0 kGy, methane did not occur during the BMP test.

The methane production by the food waste in the BMP test is estimated to be the increase of the activity of the methanogenic microorganism by accelerating the hydrolysis and the acidification according to the decomposition action of the degradable organic matter in the composite wastewater. The yields were similar. Therefore, it can be confirmed that it is applied to compound wastewater due to the physicochemical treatment mechanism by gamma ray. In the metabolic process, the cell wall peptidoglycan surrounding the protozoan microorganism was decomposed by gamma irradiation, shortening the rate-limiting step to limit the overall reaction rate in the anaerobic digestion process. Methane production was confirmed.

As a result of the change of daily gas production with anaerobic digestion, the amount of gas generated in the anaerobic digestion tank was about 600 ~ 4,500mL / day. In the stabilization step, the amount of production was about 500mL / day per 1 kg CODMn / day at about 600mL / day. It was confirmed that the production amount increases up to about 2,000mL / day per day depending on the load ratio change under impact load.

The correlation between the removal efficiency of organic matter and the amount of gas production showed that the gas production was increased in proportion to the removal rate of organic matter in the hot anaerobic digestion tank, but not in the mesophilic anaerobic digestion tank.

This is thought to be the result of adsorption and redistribution in addition to biomass organic matter removed from the anaerobic digester.

The concentration of organic matter in the sludge flowing into the mesophilic anaerobic digestion tank does not appear to be constant.

The rate of methane gas was about 42.5%, carbon dioxide was about 35%, and it was 5.6ppm. In the mesophilic anaerobic digester, methane was about 16.5%, carbon dioxide was about 56% And 2.8ppm of hydrogen sulfide. In the anaerobic digestion tank, the gas composition ratio was relatively constant regardless of the amount of gas produced.

The odor of the composite wastewater was 0 kGy compared to the 100 kGy of composite wastewater. The odor of the wastewater was 10 times higher than that of the composite wastewater. Odor was high even in a short stay for 10 days in a high temperature anaerobic digestion tank. In the case of air dilution sensory drainage, it was at least 44,814 times and a maximum of 100,000 times. Actual gamma irradiation promoted the hydrolysis by the decomposable substance, which is effective for methane production and microbial growth, and also for the reduction of odor.

Initial ammonia was 46.9ppm in the case of 0 kGy of the compound wastewater, but it was 38.4ppm (average 35.82 ppm) after 3 months. The irradiated complex wastewater of 100 kGy was 33.3ppm to 1.45ppm (average 12.79ppm). It is considered that ammonia is reduced in the product gas composition in the anaerobic digestion tank by preventing the formation of ammonia due to carbon shortage by making the environment suitable for the production of methanogenic microorganism by balancing carbon and nitrogen in the decomposition substrate (Nam et al., 2012).

The rate of change by 0 kGy was about 14 ~ 20ppm, and when it was irradiated with 100 kGy at 0 ~ 6 ppm, it was measured by low temperature GC / FPD. It can be confirmed that the concentration of sulfur is reduced by increasing the solubility efficiency of the sludge by irradiating gamma rays.

The gamma ray dose was 29.9 ppm in the high temperature anaerobic digestion tank at 0 kGy and the maximum concentration was 35ppm in about 3 months. These results were significantly higher than the exposure limit threshold, the recommended exposure limit, and the time-weighted average exposure standard (TWA) during a day's work time.

In the case of 100 kGy, the average concentration was 2.3ppm and the maximum concentration was 10.7ppm within about 3 months. Comparing the measurement results generated at 100 kGy with 0 kGy, it was found satisfactory in all aspects. Therefore, pre-treatment by gamma irradiation is considered to be a necessary pre-treatment process in the anaerobic digestion process.

In the anaerobic digestion tank, 0.63 ppm was observed at 0 kGy and increased to 1.11ppm (mean 0.72ppm). At 100 kGy irradiation, it was 0.44 ppm, but gradually increased to 1.23ppm (mean 0.46ppm). This is because in the hydrolysis step of the methanogenic microorganism growth that consumes hydrogen by acid-producing bacteria (hydrogen-forming bacteria), the complex binding of carbohydrates, proteins and fats as starting materials is converted into amino acids, sugars and fatty acids Bacteria release enzymes and break down substances by enzymes. At this time, the intermediate product plays a role of decomposing monosaccharide fatty acid, carbon dioxide and hydrogen due to bacteria during the acid production process. Therefore, it is considered that acetic acid is produced under the influence of hydrogen and acetaldehyde series is formed.

The anaerobic digestion process by the inspection of the inspection line is suitable for treating food wastewater discharged from large restaurants or agricultural and marine products market from an economic point of view. Gamma irradiation suggests an improvement in hygienic and safe food distribution structure as well as environmental problems that can improve contaminated water quality.

In conclusion, this means that the distribution process or distribution facility should be transformed from traditional markets or small traditional markets to large distribution structures or large distribution

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