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Entry into the Southeast Asian Energy Market from the Sales Promotion Viewpoint*

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Abstract

Purpose - The purpose of this study is to promote sales of the renewable energy industry and to advance into the Southeast Asian market.
Research design, data, and methodology - This study is to develop a highly efficient food waste treatment system for Southeast Asian renewable energy industry. The radiation treatment method was applied for this purpose.
Results - To investigate effects of ionization on removal of non-degradable organic matter, the results from gamma irradiation and co-digestion process was compared to those from a co-digestion process. Based on the BMP test results, food wastes were oxidized by hydroxyl radicals, and the specific methane yield was 366 mL CH4/g VS. Methane composition was 82%. A WAS/food wastes co-digestion was developed for the treated of non-degradable organic matter in food wastes. The average efficiency of non-degradable organic matter were 92.2% using the food waste co-digestion.
Conclusions - Performance of gamma irradiation and co-digestion process was superior to that of a co-digestion process (10-20%). This implies that food wastes can be high efficient co-digested by the gamma irradiation. It is believed that it will be possible to enter the Southeast Asian energy industry as a strategic technology in the overseas energy recovery industry.

Keywords: Market Entry, Sales Promotion, New And Renewable Energy Industry In Southeast Asia, Market Opening.

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

1. Introduction

Turmoil in the Middle East, rising energy prices in the United States, and evidence of global warming recently have reignited interest in the link between energy prices and economic performance(Kilian, 2008). Abundant resources and increasing demand for energy make Southeast Asia a region of rich potential for renewable energy(Dietz, 2015). New and renewable energies including solar, wind, geothermal, and biomass energy are widely used in Southeast Asia. Among these, in particular most of the food wastes in relation to biomass energy in 2005 were disposed of at the composting or feed facilities due to the prohibition of direct land filling of food wastes. Bio-gasification facilities are being expanded due to increased interest in biogas production due to anaerobic digestion for the treatment of food wastes (Zhang et al., 2007). Although the waste water generated from food wastes is generated in the waste itself, the amount of water generated by the dilution water used in the process of removing the high concentration of salt in the food for the composting and feed is greatly increased(Zhang et al., 2015). Since the ocean dumping is totally prohibited by the London Convention, it is treated as an appropriate land

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treatment alternative for drinking wastewater, and the facility is being expanded(Ju et al., 2016). However, the wastewater generated from food wastes is composed of high concentration of organic matter, and it is difficult to treat the wastewater in existing process because it contains a large amount of nitrogen(Jiang et al., 2013). Therefore, many researchers and research institutes have proposed new treatment methods in order to solve the problem of domestic wastewater. However, since the characteristics of the wastewater discharged from each country are very different, development of appropriate processing system is urgent. Anaerobic digestion is the process of converting methane and carbon dioxide into bio gas, which is the primary ingredient of methane and carbon dioxide, which is the main ingredient of methane, which can be used as a source of bioenergy as it can produce methane as a source of bioenergy(Ward et al., 2014). However, when the wastewater is directly applied to the anaerobic digestion, the anaerobic microorganisms can be inhibited by the high concentration of the degradable organic substances contained in the wastewater, and the high concentration of ammonia contained in the wastewater serves as an obstacle to the growth of anaerobic microorganisms(Yenigün & Demirel, 2013). Therefore, the method of anaerobic digestion by composing organic wastes such as sewage sludge concentrated water and combined wastewater together with the wastewater can be interpreted as one of the most ideal method. On the other hand, when the waste wastewater is mixed with the non-degradable organic matter of other wastewater, the difference in the degree of decomposition may not show a large difference, and when the livestock wastewater is mixed, a high concentration of nutrients may be introduced and adversely affect the anaerobic digestion. In addition, biomass cell walls can be the largest rate-limiting step in the anaerobic digestion of sewage sludge-concentrated water mixtures, so it is necessary to facilitate the complex anaerobic digestion process by pre-treatment of complex wastewater(Shin et al., 2015). Radiation not only has germicidal power in water treatment, but also is effective in decomposing degradable organic matter, and second chemical contamination problem can be solved because no chemical is used(Kurucz et al., 1991).

In this study, a pre-treatment system using radiation was introduced to solve the problems caused by mixing of waste water and organic waste. In addition, the bio-electrochemical complex system was used to remove the nutrients contained in the organic matter-removed mixture. Through the development of a system for treatment of high concentration wastewater, treatment of the wastewater was planned and the treatment efficiency was verified through the universal water treatment system for wastewater containing high concentration organic matter. So, the developed high-efficiency food waste disposal method is expected to promote the renewable energy industry economy in Southeast Asia and contribute to the development of biomass business.

2. Literature Review

Food wastes in Korea in 2011 were treated by feed conversion, composting, reduction, sewage-combined digestion, anaerobic digestion, feed composting, and other methods at 260 treatment facilities. In the case of recycling, Account for more than 80% of the total recycled volume(Kim & Kang, 2015). In addition, the rate of feed conversion or composting facilities is higher than that of composting facilities in the case of private facilities, and the composting rate is higher than that in the case of public facilities(Lee et al., 2014). However, in the case of negative wastewater generated by solid-liquid separation of food wastes, it has been treated by self-treatment, marine discharge, linkage treatment of wastewater treatment plant, linkage treatment of leachate treatment, consignment treatment of wastewater treatment company, it has become a reliance on land treatment methods to replace marine emissions(Min Ree, 2014). This situation is one of the biggest causes to cope with the negative treatment of the wastewater discharged from the public sewage treatment plant and the wastewater treatment plant, which are operated and operated by private facilities, because the waste water treatment subject is divided into public and private sectors.

Following the announcement of the London Protocol in 2006, which prohibits the discharge of all wastes including food wastes, the Korean government announced the “Wastewater treatment and energy conversion comprehensive measures” and are pursuing resource-saving(Hong & Lee, 2015). Nevertheless, in contrast to the plan to achieve 0% of marine dumping in 2012 from the year 2012, 35.1% of marine wastewater is treated as marine discharge(Kim et al., 2010). Since the waste water contains high concentration of highly decomposable organic matter and nutrients such as nitrogen and phosphorus, it is not suitable for direct treatment by conventional physicochemical treatment methods or biological methods(Zhou et al., 2014). Thus, many researchers and research institutes have proposed new treatment methods to address the problem of resolving the problem, but the development of the Food waste treatment facility waste water system is urgently needed to deal with Food waste treatment facility waste water marine emissions in Southeast Asia and Southeast Asia.

Nutrients in wastewater are present in the form of organic nitrogen, ammonia nitrogen (NH_4-N), nitrite nitrogen (NO_2-N) nitrate nitrogen (NO_3-N) and organic phosphorus and phosphate salts, The nutrients in the sample decompose organic matter and increase the amount of biologically available nutrients(Möller & Müller, 2012). Emissions of nitrogen and phosphorus in water can disturb the aquatic ecosystem and can act as pollutants, such as causing eutro-phication(Smith et al., 2016). Biological nitrogen removal is accomplished by two steps: the removal of these nutrients via a biological nitrogen removal process. Through the nitrification reaction, ammonia is oxidized to nitrate, and nitrate nitrogen is used as an electron acceptor through the denitrification to be removed with nitrogen gas(Wang et al., 2013). When the HRT is short in the nitrogen removal process, the contact time between the nitrifying bacteria and the ammonia nitrogen in the influent water is shortened and the ammonia nitrogen oxide is decreased. Therefore, the HRT should be increased to increase the ammonia nitrogen oxide(Liang et al., 2016). Wastewater from food wastes containing high concentrations of non-degradable organics and nutrients must take into consideration the removal of organic matter and the efficient treatment of nutrients. In this study, we investigated the more advanced treatment process by pre-treatment of food wastewater, anaerobic digestion process of organic matter removal process, and bio-fusion electrochemical reaction for nutrient treatment.

3. New and Renewable Energy Industry in Southeast Asia

It's no secret that Asia's manufacturing, industry and services sectors are growing, increasing demand for electricity across Vietnam and Indonesia(Perera, 2017). In Southeast countries, the result of industrialization was increased pollution in the power sector, which means dirty air and more climate warming greenhouse gas emissions. In spite of the rapid economic development, installing enough capacity for rapid economic development is one of the most important issues that ASEAN countries must address sooner or later. Rather than transitioning from existing, reliable and adequate fossil and nuclear energy infrastructure towards renewable energy sources driven by political will, as we have experienced in developed markets such as Europe, the USA or Japan, renewable investments in Southeast Asia are first and foremost driven by the need to increase energy capacity(Dobrott, 2016). <Table 1> shows the goals and plans for renewable energy in Southeast Asian countries.

<Table 1> An overview of renewable energy commitments made by Southeast Asian countries.
Image: Eco-Business(Shah & Cheam, 2015)

Country	Renewable Energy Target
Indonesia	Aims to raise the share of renewable energy in its National Energy Mix from 4.79 per cent in 2011 to 25 per cent by 2025.
Malaysia	Aims to raise the share of renewable energy in the energy mix to 6 per cent by 2015 and 11 per cent by 2020.
Philippines	Aims to raise the share of renewable energy's share in electricity production to 50 per cent by 2030 and triple renewable energy generation capacity from 5 GW in 2010 to 15 GW by 2030.
Singapore	No declared targets for renewable energy use as share of national energy mix. However, the government aims to have 350 MW of solar installations on public sector rooftops by 2020.
Thailand	Aims for renewable sources to provide 25 per cent of the country's total energy consumption by 2022.
Vietnam	Plans to increase the ratio of new and renewable energy sources to about 5 per cent in 2020 of the total primary energy supply and about 11 per cent in 2050. In 2010, renewables accounted for 3 per cent of the energy mix.

The Asian renewable energy market has grown by an average of 18% since 2009, making strategic importance to the Asian market increasing(Seo, 2013). 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.

4. Method

We have developed a technology that can treat waste water by combining the complex digestion technology with radiation pre-treatment and the bio-ion exchange membrane system. Optimize the solubilization and solubilization of organic matter by using hydroxyl radicals generated during radiation pre-treatment in order to decompose high concentration of non-degradable organic matter, and it is possible to treat nutrient salts stably/efficiently using biochemical process and polymer.

4.1. Influent Properties

As shown in <Table 1>, the wastewater used in this study had a COD of 518,957 mg/L, which was much higher than that of solids. It was also found that the content of carbohydrate and protein was very high. This suggests that the process may become unstable easily when the alkalinity is insufficient in anaerobic digestion, and that digestion of food waste is necessary by using complex digestion process such as macro/micro nutrient and alkaline supplement.

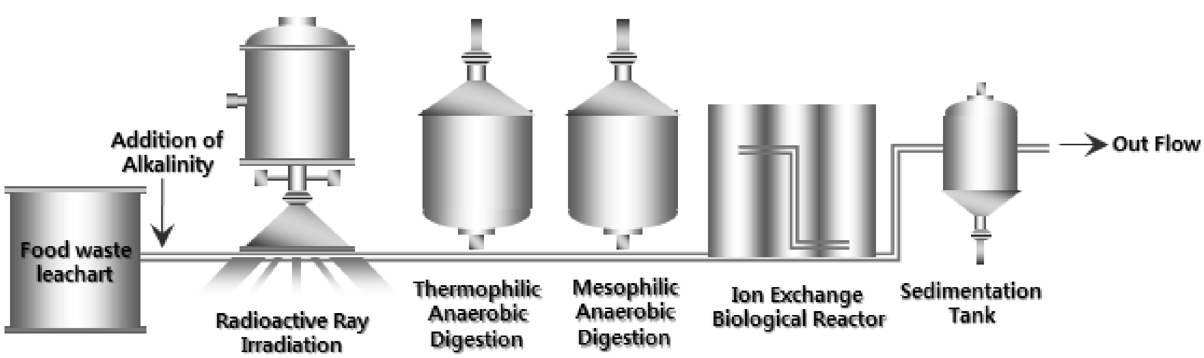
4.2. Configuration of instruments

The wastewater was mixed with the sewage sludge by removing the impurities through a 10 μm mesh sieve for the supernatant which had been separated by solid-liquid separation. To prevent spoilage due to microbial digestion prior to application of the process, the pH was adjusted to 12 using NaOH. The prepared samples were irradiated with 100 kGy gamma rays for about 17 hours and stored at 4℃ or less. Samples for influx in the process were replaced daily to minimize the effect of room temperature. The influent samples were discharged through a process consisting of a high temperature digester, an anaerobic digester of a mid-temperature digester, a bio-fusion electrochemical reactor for nitrification, and a settling tank for removal of phosphorus. The digestion tank for the extinguishing process is 5 L in volume, and it can be adjusted to 1 L unit so that the residence time can be variably operated to derive the operating condition. Overhead stir using the upper agitation motor was adopted, and the waste water was supplied through the lower valve and discharged through the side valve. And a valve capable of collecting the gas is positioned at the upper portion so that the generated gas can be discharged.

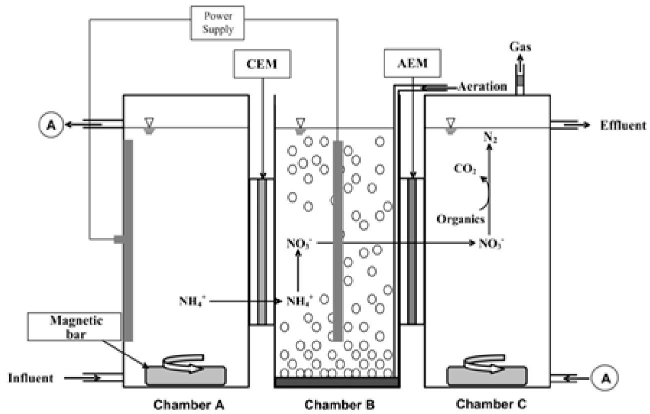
The thermophilic digester was made of stainless steel to prevent thermal deformation by high temperature, and the mesophilic digester was made of acrylic. Each digester was constructed in a double structure so that water could be supplied to maintain the temperature, and water was supplied through a separate water jacket. The temperature maintenance system kept the digester temperature by circulating the water at the set temperature with the water bath. The gas generated after the digestion was stored in the collection tank through the upper valve. When 100 mL was collected, the gas was automatically discharged and a counter recording system was established.

The sludge which has undergone the anaerobic digestion process and the organic matter has been removed has been introduced into the inorganic and organic minerals removal process through the bio-electrochemical ion exchange membrane system. The bio-electrochemical ion exchange membrane system consists largely of three chambers, and the sample is configured to be discharged through A and C chamber. A and B are separated by a cation exchange membrane and are designed to move cation such as ammonia. In the A chamber a carbon anode is attached and, in chamber B a cathode of stainless steel is attached to activate cation migration through electric force. Each electrode was composed of a system capable of generating a voltage difference through a power generator.

Chamber B and C are partitioned into anion exchange membranes, so that anions such as nitrate can move, and the migration of anions is induced through concentration gradient. The chamber A was constructed so that the role of the influent tank into which the sample flows and the ammonia in the sample can move to the B group through the cation exchange membrane based on the voltage difference. The ammonia dissociated in A is introduced into B by the voltage difference, and nitrification proceeds through aeration to be oxidized in the form of nitrate or nitrite. The sample with ammonia dissociation in group A migrates to group C, and the residual nitrate and the nitrate from group B are de-nitrified and discharged in the form of nitrogen gas.



<Figure 1> Schematic configuration of instruments



<Figure 2> The scheme of Ion exchange biological reactor

4.3. Operation condition

In order to derive optimum operation of the process, anaerobic digestion experiments were carried out on the wastewater treated with radiation of pH 12, and the conditions of each digester and bioreactor were derived. Activated sewage sludge treated with sludge was used for stabilization period of about 7 days after planting, and it was found that adaptation period for raw water after 15 days was necessary. The operating temperature of the anaerobic digester was set at 35, 55℃ considering the efficiency and economical efficiency. The residence time for the irradiated wastewater was optimized for about 10 days and the inflow was 450 mL/day Respectively. In case of single – stage digestion in thermophilic digestion and mesophilic digestion, the removal efficiency of organic matter was 50% based on total COD_{Mn}. The ion exchange biological reactor was operated under conditions controlled by the shear anaerobic digestion process.

<Table 2> Operating conditions of the digester and reactor

Condition	Anoxic Digestion		Ion Exchange Biological Reactor		
	Thermophilic	Mesophilic	A	B	C
Seeding	Activating Sludge	Activating Sludge	-	Activating Nitrification Sludge	-
pH	7~7.5	6.5~7	6.5~7	7~7.8	7.5~8.2
Temperature(℃)	55	35	25	25	25
HRT(days)	10	10	10	-	10
Input volume (mL/day)	450	450	450	-	450

4.4. Analysis items and methods

In this study, organic matter and inorganic matter were investigated in each process to investigate the water purification properties and efficiency of the wastewater through irradiation, anaerobic digestion, and ion exchange biological reactor. Total COD and soluble COD were analyzed to indirectly estimate the concentration of organic matter. As an analytical method, the amount of oxygen consumed after oxidization was measured by heating with oxidizing agent of potassium permanganate for 30 minutes and quantitated. The total nitrogen and total phosphorus contents were determined by absorption spectro-photometry after oxidation of organic compounds at 120℃ with nitrate ion and phosphate.

5. Result

5.1. Increase of solubilization rate by irradiation

The amount of methane produced by the BMP test was 366 mL CH_4/g VS and the average methane content was 82 % when irradiated with 100 kGy of gamma ray. On the other hand, methane was not produced during the BMP test if radiation was not irradiated as in the case of pH results. The activity of methanogen was directly related to the activity of methanogen, and hydrolysis and acidification of the wastewater were accelerated by the degradation of the degradable organic compounds during irradiation.

<Table 2> shows the methane emissions of food wastes from BMP tests published by previous researchers. Comparing the results of this study with the results of the previous studies, the methane emission was similar to that of food wastewater or wastewater, even though it was a mixed wastewater. This indicates that the activity of methanogen increased due to the degradation of degradable organic compounds in the wastewater by gamma rays and the increase of the hydration.

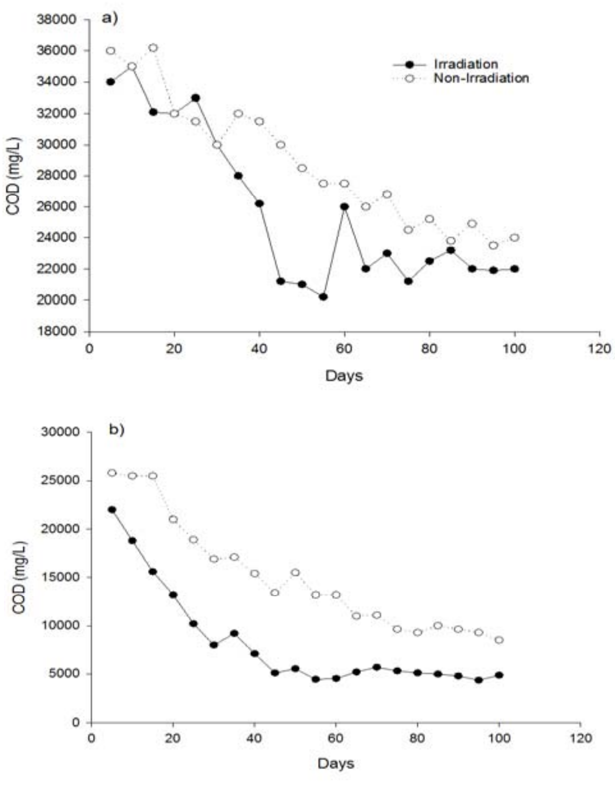
<Table 3> Results of BMP test methane production from waste water in various countries

Source	Moisture (%)	VS/TS	C/N	Methane yield (mL CH_4/g VS)	Ref.
Food waste leachate	84	91	11.1	478	Lee et al. (2014)
Restaurant	74	87	14.8	348	Zhang et al. (2007)
University hall kitchen	78	n.a.	n.a.	229	Zhang et al. (2015)

5.2. Difference due to process operation condition

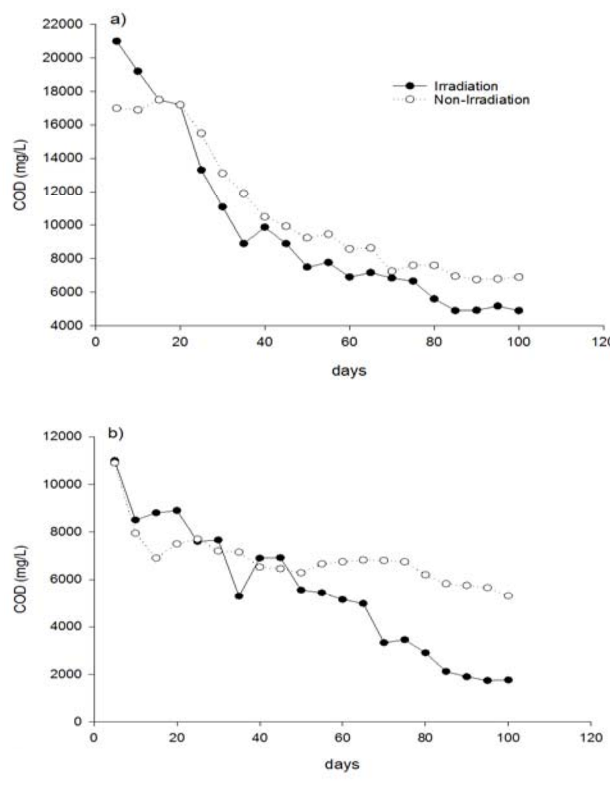
The solubilization rate of the wastewater samples increased by more than 50% according to irradiation, and the change of the anaerobic digestion efficiency of the wastewater samples by irradiation was confirmed. The removal efficiencies of total COD were 51% in the irradiated samples and 48% in the non-irradiated samples in the thermophilic digester. However, there was a difference in the tendency. The radiation irradiation samples showed a relatively stable removal efficiency in about 40 days, while the non-irradiation samples required about 80 days, and the stabilization period was twice as long. This is considered to be the result of radiation irradiation in which the solubilized organic matter is relatively increased and appears to be stabilized in a relatively short period of time.

The differences in organic matter removal with irradiation were more evident in the mesophilic digesters. At the final removal efficiency, the irradiated samples showed a removal efficiency of about 90%, while the non-irradiation samples showed 80% removal efficiency. Regardless of the irradiation, irradiated samples showed higher stabilization period at the mesophilic digestion, suggesting that other microorganisms were involved in the anaerobic digestion. In addition, the final decomposition efficiency did not show any significant difference, but the efficiency of removing organic matter was about 80% or more in a short period of time.



<Figure 3> Changes in total COD depending on irradiation a) in thermophilic digestor and b) mesophilic digestor

The increase of solubilized organic matter by irradiation has been found to affect the rate and efficiency of total COD removal by anaerobic digestion. Increase of solubilized organic matter by irradiation resulted in increase of soluble COD. The efficiency of removal of soluble COD by anaerobic digestion showed a more significant difference between irradiated and unirradiated samples. The initial soluble COD concentration of irradiated samples was about 1.5 times higher than that of non-irradiated samples. The concentration of the soluble COD tended to decrease with the time required for stabilization as the digestion started in the high temperature digestion tank. The final removal concentration of the non-irradiation sample was about 7,000 mg/L while the final removal concentration of the irradiated sample was about 4,900 mg/L. The removal efficiency was about 60% for the non-irradiated sample, about 80% for the irradiation samples. The efficiency of removal of soluble COD by irradiation was more evident in the mesophilic digester. The final removal efficiency was 68% for non-irradiated samples and 92% for irradiated samples. Compared with non-irradiated samples, both the total COD and the soluble COD showed high removal efficiency, and it was confirmed that the stabilization took a short time. It is expected that the efficiency of methane generation will be increased by the removal of organic matter.

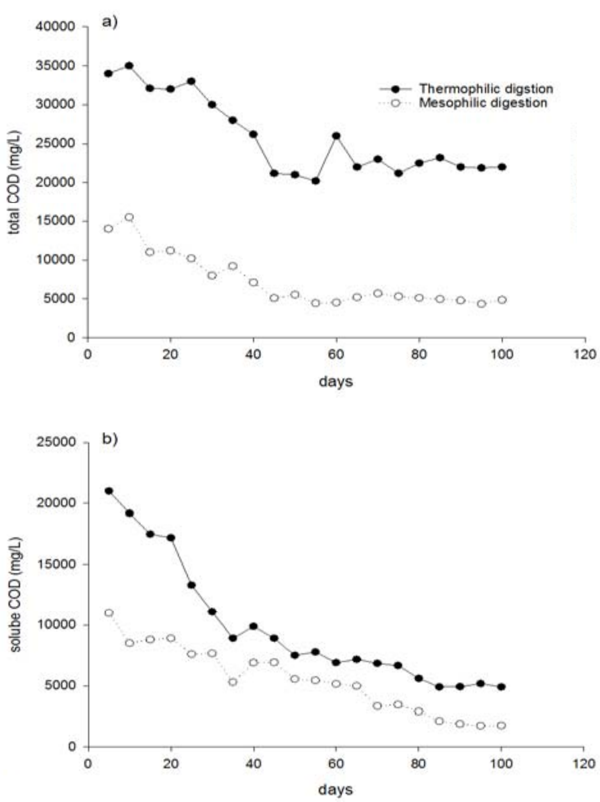


<Figure 4> Changes in soluble COD depending on irradiation a) in thermophilic digestor and b) mesophilic digestor

5.3. Reduction of organic matter by anaerobic digestion

5.3.1. Operation of complex digester and organic matter reduction

The thermophilic and mesophilic digester were connected in series to perform the complex process. The samples in the inflow tank were flowed into the refrigerated sample daily to prevent decomposition and normal temperature digestion of the sample. The operation was the same as that of single-phase digestion tank. After 30 days of stabilization and adaptation period after feeding, normal samples were introduced. The first anaerobic digestion process of the thermophilic digester was similar to that of the single digestion digester, and the total COD was reduced by about 50%. The sludge containing primarily organic matter was introduced into the mesophilic digester, which was reduced to about 5,000 mg/L after stabilization over a period of time. In the case of soluble COD, it was confirmed that the operation was reduced to about 5,000 mg/L in the thermophilc digester and to about 1,500 mg/L in the mesophilic digester. Removal tendency was found to be higher than total COD, which is due to the higher proportion of solubility COD in the raw water than COD induced by solids.



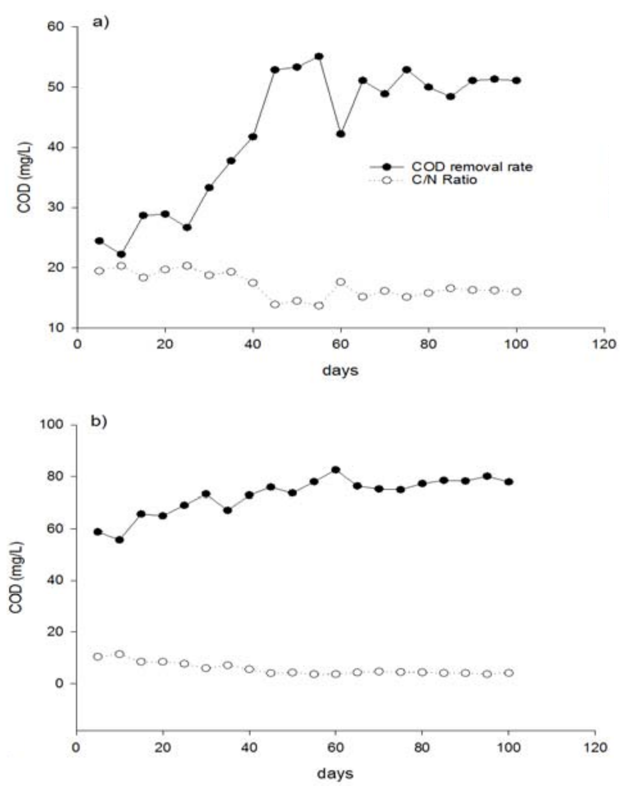
<Figure 5> a) Total COD and b) soluble COD removal by continuous anaerobic digestion

5.3.2. Removal efficiency by C/N ratio change

The estimated TOC was about 75,000 mg/L and the TN was about 3,000 mg/L. Based on this, it is estimated that the C/N ratio is about 25, which is the most efficient digestion for anaerobic digestion.

However, as the anaerobic digestion progresses, the TN is maintained, but the carbon in the sludge is converted to methane or carbon dioxide, and the C/N ratio gradually decreases, and attention should be paid to the formation of soluble ammonia.

TN showed no change, and the C/N ratio was decreased by the removed organic matter. Especially, the decrease of C/N ratio was larger in the mesophilic digester, where the sludge with organic matter decreased in the thermophiic digester. As the C/N ratio decreased, the removal efficiency of the organic matter was expected to decrease. However, after the stabilization step, the removal efficiency of the organic matter was further increased. It is considered that the untreated TN is not converted to soluble ammonia, and the byproduct of the acid formation reaction by the first decomposition is due to the buffering action on the alkalinity.

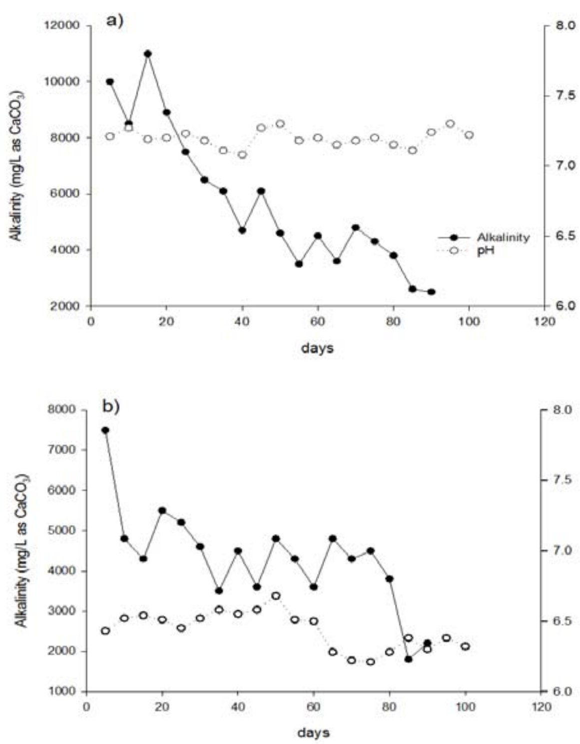


<Figure 6> Changes in C/N ratio and COD removal rate in a) Thermophilic digester and b) Mesophilic digester after continuous anaerobic digestion

5.3.3. Alkalinity and pH

In general, an increase in ammonia nitrogen in anaerobic digestion increases the alkalinity and leads to an increase in pH. The increase in ammonia nitrogen concentration directly affects the rise of pH, and the carbon dioxide and ammonia generated in anaerobic conditions combine to form bicarbonate and lead to alkaline supplementation by bicarbonate.

The initial alkalinity was attributed to the NaOH added for the optimal radiation efficiency, and the alkalinity remained about 6,000 mg/L as $CaCO_3$ after the digestion tank was stabilized. In this study, it was confirmed that the alkalinity is continuously decreased in the high temperature digester after stabilization of anaerobic digestion. In addition, the pH tended to decrease as a result of alkaline depletion due to acid production. As in the operation results of the single phase digester, it was confirmed that the pH was lowered in the middle temperature digester.

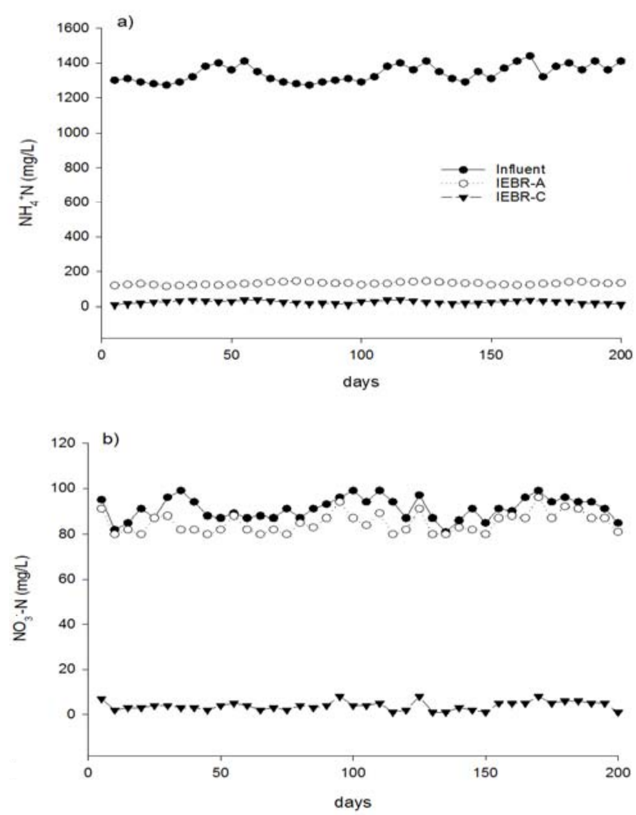


<Figure 7> Changes in Alkalinity and pH in a) Thermophilic digester and b) Mesophilic digester after continuous anaerobic digestion

5.4. Ion exchange biological reaction

5.4.1. Nitrogen fate

The irradiated wastewater was subjected to an anaerobic digestion process and then put into the IEBR process to remove residual organic matter and nitrogen. It was operated according to the process review and optimization operation conditions in the IEBR for the standard samples, and the nitrogen removal efficiency was examined through analysis of ammonia and nitrate. Ammonia in the influent was about 1,300~1,400 mg/L, and the samples which had undergone the complex digestion process flowed relatively constantly due to the retained alkalinity. As a result of the HRT maintained for 10 days, the ammonia immediately flowed from chamber A to chamber B, and the residual amount was maintained at about 50 to 100 mg/L. Some residual ammonia was partially oxidized during the stay in group A and then moved to the chamber C like the sample. Afterwards, the result showed that all the ammonia was removed. The behavior of nitrate was also stable and showed more than 95% removal during the operation period. The nitrate concentration of 100 mg/L or less was analyzed and the concentration of nitrate was similar to that of the influent during the stay period of chamber A. The remaining nitrate in the sample moved to the chamber C was discharged as nitrogen gas through the denitrification, and the result was confirmed to be maintained at 30 mg/L or less.



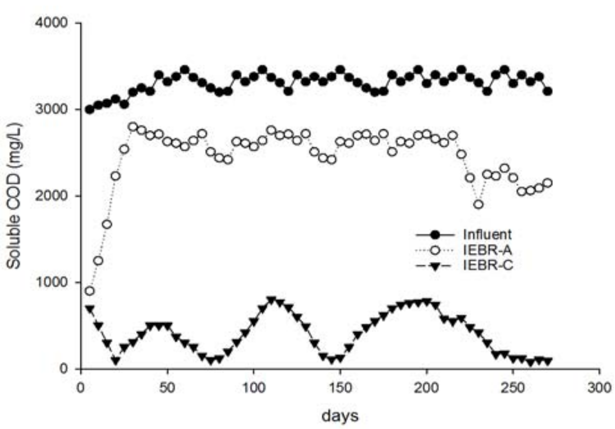
<Figure 8> Behavior of ammonia and nitrate in ion exchange biological reactor

5.4.2. Organic matter fate

Unlike the relatively stable form of nitrogen, organic matter has a tendency to change. The influent soluble COD value was maintained at about 3,000~3,500 mg/L. The initial nitrification sludge was maintained at low concentration at the initial introduction in chamber A, but it was ascended gradually after the influx and maintained at about 2,500 mg/L.

In chamber C, various processes were introduced with the aim of complete removal of organic matter. The organic matter flowing into the A group moved to the chamber C and was maintained at about 600 mg/L. However, it was confirmed that the organic matter was continuously decreased through the forced sludge removal. This is considered to be the result of re-elution of the organic matter adsorbed on the settled sludge, and then the concentration of the organic matter again increased at the same time as the operation of the agitator. Stirring was carried out for homogeneous distribution of stable organic matter and nitrogen, and intermittent aeration was performed as a device for reducing organic matter.

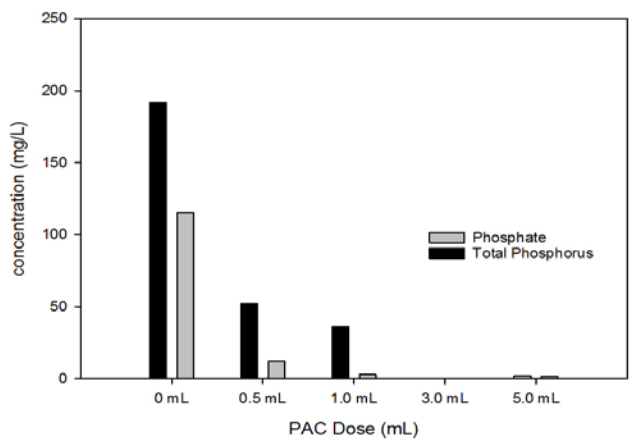
The main purpose of the intermittent aeration was to remove phosphorus, but the cycle was shortened to remove organic matter by aeration. The introduction of the intermittent aeration process resulted in the reduction of the organic matter in the chamber C and prevented the re-elution by the sludge accumulated at the bottom through the upper agitation. The intermittent aeration process was introduced in chamber A due to the reduction of organic substances by the intermittent aeration process confirmed in chamber C, and afterwards, it was confirmed that soluble COD of about 20% or more was further removed.



<Figure 9> Change of removal efficiency of soluble COD by Ion Exchange Biological Reactor operation

5.5. Reduction of phosphorus by precipitation

In order to reduce the phosphorus concentration of the effluent, the coagulation experiment of the phosphorus component in the wastewater mixed wastewater was performed using the polymer coagulant PAC through the Jar-test as shown in the figure. The total phosphorus and phosphate concentrations of effluent were 192 mg/L and 118 mg/L, respectively. The total phosphorus concentration was decreased to 52, 34, 0.15 and 2.0 mg/L as the PAC injection amount was increased to 0.5, 1.0, 3.0 and 5.0 mL based on 1 L of the target effluent. Phosphate phosphorus concentrations were 12, 2.9 and 0.12 and 1.7 mg/L, respectively. The treatment efficiency of total phosphorus according to the amount of coagulant injected was 72.9, 82.3, 99.9, and 99.0% at PAC doses of 0.5, 1.0, 3.0 and 5.0mL, respectively. The treatment efficiencies of phosphate phosphorus were 89.8, 97.5, 99.9 and 95.6%. The pH of the effluent was 9.17 and the pH was decreased as the amount of PAC was increased through Jar-test. The pH was 7.70, 7.27, 7.25, 6.93 when PAC was injected at 0.5, 1.0, 3.0 and 5.0 mL. Therefore, the optimum amount of coagulant for effluent concentration reduction was 3.0 mL/L. The effluent treatment efficiency was 99.9% and the pH reduction was also 7.25.



<Figure 10> Calculate optimal PAC injection dose for phosphorus concentration reduction

6. Conclusion

6.1. Summary

This study first develops a high efficiency food waste treatment facility and then explores and distributes sales to the renewable energy industry in the Southeast Asian market with the developed high efficiency wastewater system. First of all, this study was conducted to evaluate the performance of disoriented organic materials in the combined digestion of drinking wastewater through gamma-ray ionization to promote the production of renewable energy through food waste.

Through the ionization reaction using radiation, the degradable organics treatment performance was assessed in the combined digestion of the waste water. In order to investigate the effect of ionization reaction in the pre-treatment of radiation, complex fire extinguishing process without pre-treatment of negative wastewater was operated simultaneously and the results were compared and evaluated. In the complex digestion process, the degradable organics of the wastewater decreased by 92.2% on average. These results show a high treatment efficiency of about 10-20% as compared to the results without using the radiation pre-treatment. By the solubilization effect of the decomposable organic substances by the ionization reaction, a more stable and efficient complex digestion process can be achieved Respectively. From the technical point of view, it is possible to greatly reduce the environmental pollution load by decomposing non-degradable materials of food wastes by using radiation and inducing complex digestion with organic matter, nutrient salts and pathogenic microorganisms, which are representative environmental pollutants, together with sewage sludge or livestock wastewater.

Bio-electrochemical process and biological filtration membrane process were further installed to develop a technology to lower organic matter and nitrogen concentration in food wastes to below "Released water quality standard". Radiation Technology Combination Combined digestion process and biological treatment process eliminates pathogenic microorganisms, heavy metals, trace pollutants, and ecosystem disturbances which are typical environmental pollutants of rivers and lakes It can be done. Economic and social aspects, it is possible to produce biogas and recover renewable energy through digestion process, and it is expected that the cost of extinguishing sewage sludge and animal manure through complex digestion will be reduced. Also, it is expected that the shortage of residence time will reduce the final disposal area of food waste in the landfill, which will reduce the indirect cost of the technology itself.

6.2. Implications of research

Through the development of food waste treatment technology for complex digestion process, it is possible to export to the source technology of other countries, in particular Southeast Asia, classified as water scarce country, and it can be utilized as Strategic technology of overseas energy recovery industry. As a difficult problem that needs to be overcome urgently nowadays, it has secured the leading technology in the rapidly growing market every year and it is possible to reduce the processing cost by releasing without the additional process because of the elimination technology through the IEBR Do.

6.3. Product costs and market entry

The cost of treating renewable energy in any country is a very important issue in applying renewable energy technologies. The cost of renewable energy-fired electricity is greater than that of its main competitor, combined-cycle natural gas (natural gas or synthesis natural gas made from coal), and also, renewable energy sources are capital intensive compared with combined-cycle natural gas (Carbaugh & Brown, 2012). Although there is a burden of adding a radioactive treatment facility to the existing process, it is expected to reduce the treatment cost by increasing solubility COD and increasing anaerobic digestion efficiency due to decrease of solids, by increasing the biogas production rate. Four factors raise the transaction costs of assigning property rights: (i) scientific uncertainty regarding mitigation benefits and costs; (ii) varying preferences and perceptions across heterogeneous populations; (iii) asymmetric information; and (iv) the extent of compliance and new entry(Libecap, 2014). Among these factors, particularly the transfer of property rights related to high-efficiency wastewater treatment technology, it is believed that it will be possible to enter new markets in Southeast Asia and to open new markets. Generally, renewable resources typically do not belong to proprietary companies. Because government plays such a prominent role, a competitive model is not descriptively accurate nor is one with a benign dictator at the helm equating social marginal benefits with cost(Brown, 2000). The non-exclusive structure of the new and renewable industries can be a great opportunity and advantage for the market entry and market opening of the Southeast Asian market. Thus, it is expected that this cost-effective high-efficiency treatment technology will be a great advantage for the advancement and distribution of new and renewable energy industry in Southeast Asian market.

6.4. Limitations of research

There are various types of renewable energy industries in Southeast Asia such as solar, wind, geothermal and biomass energy. However, this study focused on biomass energy in particular. Therefore, it is necessary to develop specific models of market entry by examining the specific economic and cost-effective aspects of the new and renewable energy industry types in the future.

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