1-2 Outcomes in the Second Year

Waste Management Research Center
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1. Outline of the partnership project

The “partnership” project of Waste Management Research Center of Okayama University is tackling the research subjects which meet the governmental needs for solution of solid waste problem by collaborating with cooperative universities and local governments in Asian and Pacific countries, and also having a purpose to cultivate the student to be an international human resource by giving students research experience in the collaborating countries and obtain communication ability through his/her participation in the collaborative research. In this partnership project, the project members from Okayama University were divided into two groups: international practice group and technology support group, and individual in each group has proceeded with the practical research. The technology support group engages in the study which can be applied for practice within short term, and also visit Asian and Pacific countries with students in order to watch the target site and have a research meeting with cooperative researchers. The international practice group looks for the needs of local government in terms of solid waste problem in the target city of Asian and Pacific countries in order to transfer the information to the technology support group. Therefore, the member of the “partnership” project often reports the research progress or presents the experience obtained from the oversea research site in the monthly committee meeting to share the individual information with everyone. In addition, for every member to grasp the progress of “partnership” project, the fruits of each member is presented not only in the annual debrief meeting but also in the midterm debrief meeting.

Major research columns in this “partnership” project are ①Utilization of bio-char (Dr. Azhar and Dr. Maeda), ②Extraction of organic compounds (Dr. Kimura and Dr. Nagare), ③Composting of food waste (Dr. Kimura and Dr. Marutani (UOG)), ④Water management of landfill site (Dr. Takeshita and Dr. Komatsu), ⑤Waste component analysis and prediction of the generation (Dr. Fujiwara and Dr. Matsui), ⑥ Development of evaluation method for sound material-cycle society (Dr. Abe and Dr. Ujihara).

At present time, it is difficult to construct the municipal solid waste incineration which requires high initial cost and high maintenance cost in Asian and Pacific urban area except special mega city. Thus, we are interested in introducing carbonization process to the Asian and Pacific countries due to advantages of the process, such as variety utilization of the product “char” and lower implementation and operation cost. Further advantages of the carbonization process are the reduction of organic waste

component from viewpoint of waste treatment, storage of carbon fuel for future from viewpoint of energy saving, reduction of carbon dioxide emission from viewpoint of low carbon society, and utilization of the product "char" as adsorbent and soil conditioner, and so on. To ensure the possibility in application of carbonization process, a research on growth improvement of the vegetable which is planted in the mixed soil with the char which is produced from organic waste of Asian country, is going on. Extraction of organic compounds in solid or liquid waste by special technology is available in the case of extracting precious or valuable components. The implementation cost will be a key factor to diffuse the extraction method. Since final landfill facility has a long life span, it is important that the facility is constructed at the place with low environmental contamination risk and reliable lining system is equipped. Especially, to prevent leachate water from contaminating ground water, safety design and control in terms of leachate is necessary. Therefore, the applicability of new measurement technology of ground water is interesting theme in this project.

We sometimes are amazed at the lack of solid waste generation data and composition data in Asian and Pacific countries. In Japan where the solid waste is generally incinerated, the calorie of waste is important information to control the incinerator stably, so periodical waste component analysis is necessary. However, developing Asian and Pacific countries need not to do such costly analysis because all waste are directly disposed in the final landfill. This is one of the reasons why the lack of the waste physical information. In this project, to establish the method to collect basic information of the waste, we are conducting waste characterization survey and estimation of the waste characteristics through questionnaire survey. In addition, future generation of solid waste is projected using economic data ~~so as~~ to identify the direction of the solid waste management based 3R activities. By the way, when the material movement within a district or between districts is evaluated from viewpoint of resource recycling, we need a certain evaluation index. One of the popular evaluation indices is "ecological footprint", which is the method to translate every production factors and environmental factor in terms of human activity into space of land, as a common index.

As I mentioned above, the "partnership" projects covers wide research area of solid waste while overlapping at common area in small portion. Concrete activities of each group will be described below.

2. Technology support group

Technology support group engages in application research intending to transfer the technique to Asian and Pacific countries. In the second year of the project, to consider application in the oversea site, real organic waste in the targeted country is used as an experimental sample. In the experiment of component extraction using super critical water used nut-shell produced in China. As for research of bio-char, a research of

bio-char production in reactor and a researcher of bio-char utilization for agriculture well collaborate with each other, and they has a plan to have experiment under collaboration with Hue University, Viet Nam. As for the research on food waste composting (in Guam), city mayor of Guam, a professor and a personnel of University of Guam (UOG) were invited to Okayama University and visited some places to Japanese composting technology. Recently, the guests started to collect waste cooking oil in Guam. In addition, a researcher of Okayama University, stayed at UOG long time to carry out experiments on making compost. The research activity of food waste recycling is developing to collaborative experimental research. Experimental study on extracting organic compounds in livestock waste water was conducted in this year.

In Asian and Pacific countries, landfilling is common for waste disposal. Landfill technology is changing from the simple open dumping style (simple stacking) to the sanitary landfilling style which extracts leachate waste through drain pipes, moreover, semi-aerobic landfilling which utilizes natural air ventilation is recently introduced gradually. In the country in the zone of tropical rainforest, the landfill site should be constructed at the place with less grand water streams. From this point, technology development for ground waste monitoring is conducted in the project. Outline of each research is described as below.

1) Extraction of organic component from waste

Utilization of Subcritical Water to Separate Components of Biomass

In order to develop a simple method for complete use of biomass, extraction from biomass by subcritical water was investigated. The extraction at 200^{o}C for 15 min gave the highest concentration of reducing sugar and radical scavenging activity in the extracted solution. The residue could be used for materials replacing a part of starch for preparation of biodegradable starch foam. Addition of the residue at 20%(w/w) increased the value of the flexural modulus for the foam plate to 1.7 times of that for the plate using only starch. Both extracted solution and residue after subcritical water could be used effectively.

2) Production of bio-char

Development of Technologies for the Utilization of Agricultural and Forestry Wastes: Preparation of Biochar from Coconut Husk and Rice Husk

In this study biochar was prepared by pyrolysis of coconut and rice husks. The effect of pyrolysis temperature (400, 450 and 500 °C) and the rate of heating (10 °C/min or °50 C /min) on the yield and properties of the biochars were investigated. The char yield decreases with increase of heating rate and increases with the decrease of pyrolysis temperature. Higher pyrolysis temperatures resulted in higher surface area with a maximum at 450 °C for rice husk biochar and the specific surface areas of coconut husk biochar (CHBC) was lower than the rice husk biochar (RHBC). Rapid heating resulted in slightly higher water adsorption capacity, however no correlation of

pyrolysis temperature with the water adsorption capacity of biochar was observed. Water adsorption capacity of CHBC was higher than the RHBC. Higher pyrolysis temperature and faster heating rate resulted in slightly higher pH of the biochars in water. CHBC has higher pH than the RHBC due to higher alkali metal content in CHBC. The highest biochar-induced CO_2 emissions were observed from the samples containing the CHBC prepared at lower temperatures and decreasing emission with increasing pyrolysis temperatures.

3) Soil improvement by using bio-char

Characteristics of biochar materials produced from coconut shells and rice husks for soil application

Our hypothesis of the study was that biochar materials produced from different raw materials and temperatures showed different effects on soil quality improvements and therefore vegetable yields. In FY2011, we examined some chemical characteristics of biochar materials produced from coconut shells and rice husks that were easily available as agricultural wastes in developing countries in the Asia-Pacific region. As a result, different raw materials and temperatures influenced chemical characteristics of biochar materials. Biochar from rice husk at higher temperature contains more silicon, which would be beneficial for crop growth. Ammonium–N (NH_4-N) and phosphate–P (PO_4-P) were considerably extracted at pH 1, especially from coconut shells biochar produced at higher temperature, as compared with other conditions. The contents of these nutrients were however small when considering fertilizer effect to crop growth.

4) Extracting organic compound from livestock waste water

Development of Treatment Process for Wastewater from Milking Parlor

Milk from diseased cows cannot be consumed so that to be disposed. In this research, a new treatment process of this milk (wasted milk) was studied from a view point of resource recovery to make the treatment sustainable. In fiscal year of 2003, a prototype of the process was developed, and treatment efficiency was studied; 75% of protein (casein) was removed as sediment. 97% of carbohydrate (lactose) was removed in fermentation process, while 26% of that was transformed into lactate.

5) Ground water monitoring at final disposal site

Parameter estimation for numerical analysis of groundwater seepage and mass transport in final disposal site

It is important to estimate the behavior of the groundwater seepage for evaluating of performance in the waste final disposal site. And, that the quantity of the leachate with the rainfall infiltration is reduced greatly contributes to the reduction in the control cost after the land fill completion. Then, this study focused the dielectric method which measured amount of water content, and the examination of the applicability on groundwater around the disposal site and infiltration in the disposal site, the technique which measures the migration phenomenon of the

leachate was made to be a purpose. As an effect expected here, it is mentioned that that the evaluation technique based on measured data is established as an Asia region peculiar application technology becomes possible.

Concretely, in this year, the examination on dispersion length necessary for advection numerical analysis as a base of effective porosity and dispersion coefficient was carried out.

3. International practice group

International practice group conducts research which is useful for strategy of solid waste management under the collaboration with faculties of cooperative university and government officials. In this year, we promoted visit and invitation by university professors and local government officials between Okayama University and Okayama city, and Institute of Technologi Bandung (ITB) and Bandung city. We visited Indonesia with three Okayama city officials, and held 3R seminar and solid waste management expert meeting in ITB. After that, in reverse, we invited ITB lecturer and three heads of departments of Bandung city to Okayama. As for Guam, we invited city mayor of Dededo city, a professor and personnel of UOG, and they visited composting facilities and waste treatment facilities, and discussed with Okayama city officials about introducing waste treatment technologies to Guam. In both cases, collaboration group among Okayama University, Japanese local government (Okayama city), foreign university (Institute of Technologi Bandung in Indonesia, and University of Guam, in US Guam), and foreign local government (Bandung city in Indonesia, and Dededo city in US Guam) was established and had a meeting. This is one of the achievements in the “partnership” project. By keeping collaborative relationship, we will continue to conduct practical research activities.

In this year, a researcher visited UOG and conducted experiments on food waste composting with a researcher of UOG, which accelerated the collaboration research of composting. On the other hand, Okayama University and UOG have collected information of household solid waste in Guam through questionnaire survey. In this year, responds to the questionnaire were summarized and concluded. Furthermore, being integrated with economic data, future waste generation driven by growth of population and tourism was projected and analyzed. In Viet Nam, component census for household waste and business waste was conducted under the collaboration with Hue University. This will be a first trial of large scale waste component census in Hue. As for China, study on development of evaluation index for sound material-cycle society was proceeded, and a method of evaluating sustainability based on decupling concept was applied. Concrete activities of each group will be described below.

1) Recycling of organic food waste

Potential food waste management system for agriculture in Guam

For Year 2 (2011-2012) of the project, two activities were performed; (a) to observe food waste management systems in Japan, and (b) to conduct a study on making compost using available natural resources and food waste in Guam. The Japan tour was very successfully since after returning to Guam, a pilot study on waste oil collection was conducted by tour participants to put

into action to educate the island community. The pilot project was also linked with a commercial waste management company to support our program. A compost study is ongoing to gather more data on how to manage the system. The black soldier fly (*Hermetia illucens*) was recently found in the food waste composting box.

2) Projection of future solid waste generation based on input and output table

Analysis on solid waste generation of Guam influenced by growth of population and tourism

Based on socio-economic data of Guam, the amount of future waste is projected in each scenario that assumes different population increase of residents and tourists. Future population is re-projected to fit actual population in past years. To consider the economic ripple effect, input-output table of Guam is developed and used. Composition of household solid waste is set by referring the result of questionnaire survey which was conducted under the research collaboration with University of Guam. Under the calculation condition that is annual 5% population increase and 1.5 times tourist expenditure of 2007 at 2020, the amount of solid waste in 2020 was 1,158,295ton, that is almost twice of that in 2007. Finally strategy for appropriate future solid waste management was argued.

3) Scenario evaluation of introducing new sold waste management to Bandung city, Indonesia

Partnership project of solid waste management in Bandung, Indonesia

In this project, in order to identify issues in the current waste management of Bandung City and in the promotion of 3R, under the partnership among four: Okayama University (OU), Okayama city, University of Technology Bandung (ITB) and Bandung city, we had a solid waste management (SWM) experts meeting and a 3R Seminar in ITB, also OU invited a lecturer of ITB and 3 city officials of Bandung. As for the collaborative research with ITB, we carried out to develop an evaluation modeling of new SWM which can reduce landfill waste amount by introducing household waste separation, composting, methane fermentation, incinerator, and so on. Moreover we tried to develop a model to evaluate the impact of the new SWM on the present recycling material society.

4) Survey of waste composition analysis for household waste and business waste in Hue, Viet Nam

Commercial and institutional solid waste generation and relevant factors: Case study in tourism city - Hue, Vietnam

The major focus of this study was to estimate the generation and characteristic of waste generated from the commercial and institutional sectors in a tourism city, Hue city at central of Vietnam. The main achievements were shown as follows: The waste generation rate (kg/unit/day) was calculated and discussed by various business scale indicators. Waste compositions were classified in 10 physical categories and 54 sub-categories. The high potential of compostable components (food waste and garden waste), recyclables materials (plastic and paper), and reducible wastes (food residues) in commercial and institutional sectors were identified. The interrelationships between the waste generation and business scale indicators were explored. This is

the first step for developing predictive models and planning waste management system. By the Monte Carlo simulation, the interval estimation for total waste generation in Hue was simulated and estimated. Through the sensitive analysis, the components with high contribution to the result variation were clarified; these will be considered and improved for next surveys and researches.

5) Development of evaluation index for sound material-cycle society

Development of indicators for the establishment of a sound material-cycle society

China's sustainability assessment based on decoupling concept: By using Ecological Footprint

This study was undertaken to develop a new assessment index for the creation of a recycling-oriented society and make specific policy proposals by applying the indicator to the Asia–Pacific region. This year, we performed a sustainability assessment of China as a whole, with some regions having different characteristics in the country based on the decoupling concept using the ecological footprint (EF) concept, which has been drawing attention in recent years.

The analysis revealed the following. 1. The EF indicator value of China increased constantly during 1995–2010. The growth after 2000 was particularly notable. 2. The EF indicator value per capita of the city of Shanghai (urban characteristics) is 2.5 times that of the province of Henan (rural characteristics). 3. Growth in the EF indicator values of Qinghai Province (suburban characteristics) and Henan Province are high, not only because of changes in the industrial structure, but because of such factors as changes in dietary habits. 4. The decoupling assessment based on the EF indicator values and GDP has revealed that although China as a whole is in a state of "relatively good decoupling," the rates of change in the EF indicator value and GDP are proportional to each other. 5. Tendencies in the rates vary significantly among different regions.