Abstract

[Research Title]

Development of Advanced Energy Conversion Technology Systems for Utilization of Radioactively-contaminated Biomass and Implementation Scenarios Towards Decarbonized Society

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Principal Investigator :	Kuramochi Hidetoshi
(PI ORCID) :	ORCID0000-0003-2992-8358
Principal Institution :	National Institute for Environmental Studies Tsukuba City, Ibaaraki, JAPAN Tel: +81-29-850-2841 Fax: +81-29-850-2840 E-mail: kuramochi.hidetoshi@nies.go.jp
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[Abstract]

In subtheme 1, we revealed the behavior of radioactive cesium (r-Cs), such as the r-Cs concentrations in two kinds of combustion residues and the partitioning ratio of r-Cs between the two residues, in woody biomass combustion power generation facilities dealing with conventional wood chips in Fukushima. These findings will be useful for similar facilities that are under construction in Fukushima. To use wood bark as a new feedstock for power generation, we built two types of laboratory-scale reactors for combustion and gasification and then investigated r-Cs behavior during the combustion and gasification of wood bark samples. The results indicate that the bark could be utilized as feedstock for woody biomass combustion or gasification. Furthermore, we suggest that it is useful for preventing biochar melting since with woody biomass gasification, biochar is produced as waste. Finally, we evaluated the possibility of utilizing the biochar as a soil additive. From two safety evaluation tests of biochar samples, we demonstrated that it can meet the domestic standards for soil additives.

In subtheme 2, we investigated the integrated carbon recycling processes of pyrolysis and gasification and biological treatment processes, such as anaerobic digestion, to effectively utilize residues, including carbon dioxide generated in each unit process. The use of biomass incineration ash, digestate residues, and CO_2 in the pyrolysis of biomass has been shown to result in a significant increase in combustible gas and a reduction in CO_2 during pyrolysis and gasification. In addition, the resulting pyrolysis residues, such as biochar, were found to enhance the fermentation-promoting effect through microbial electro-symbiosis in anaerobic digestion and CO_2 bio-methanation. Not only was the continuous addition of 1% biochar to anaerobic digestion effective in improving digestion performance, it was also found that even if the biochar was contaminated with r-Cs, most of that was present in the solids of the digestate, and only a small amount was in the water. The low concentrations of r-Cs in the water (a few Bq/kg) did not pose a significant safety problem.

In subtheme 3, using the technology developed in subtheme 1 and 2, we developed social scenarios that

were centered on a biomass energy system that can contribute to both recovery from the disaster and decarbonization of the coastal region (the town of Hamadori) in Fukushima Prefecture. We developed general estimation methods and a regional database of biomasses by reviewing numerous studies and regional social statistics for the potential amounts of woody, agricultural, and other biomasses in Fukushima Prefecture. Regarding social implementation and the supply chain, we proposed a sustainable scenario for installing biomass energy power generation facilities in the new industrial area in Hamadori. A catalog of case studies was also proposed for electric and heat technologies, including collaborations with other consumer sectors in Japan, and we stressed the installing scenario as recovery progresses. Finally, future local energy systems that combine a small-scale cogeneration plant with a methane fermentation system were designed and analyzed from the viewpoints of mass flows, the economics of the operations, and their social effects on the region.

[References]

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