

## 【Grant-in-Aid for Scientific Research(S)】

### Integrated Disciplines (Environmental science)



**Title of Project :** Development of system dynamic model of plantation to evaluate the sustainable production of crops by appropriate recycle of biomass residues

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Research Area : Environmental science, Sustainable and environmental system development

Keyword : Biomass utilization, recycling and LCA, sound material recycle system

#### 【Purpose and Background of the Research】

System dynamic model to simulate the behavior of plantation system will be developed to evaluate the optimal management with recycle of biomass residues. Information and experimentally observed data in various plantations in Sumatra will be used for the model development. The model can be used to simulate and evaluate the following factors;

- 1) Optimal management to increase the fertility of the cultivation field by controlling the soil mineralization, and thus the yield of crops.
- 2) Development and evaluation of treatment and recycle system of various biomass residues to produce compost, livestock feed, biogas for energy, and electricity. And then,
- 3) Potential of plantation to supply energy and biomass for the local area after the captive use of them for the self-support local area.

#### 【Research Methods】

Plantation system is catabolized into three zones as shown in Fig.1. Zone-1 shows cultivation field of plantation where behavior of soil ecosystem such as bacteria, fungi, microbial grazer, litter transformers are investigated as well as the material flow analysis of carbon, nitrogen, and so on under tillage and no-tillage condition. Based on the observed results, organic degradation rate equation will be derived by the modification of Roth-C model.

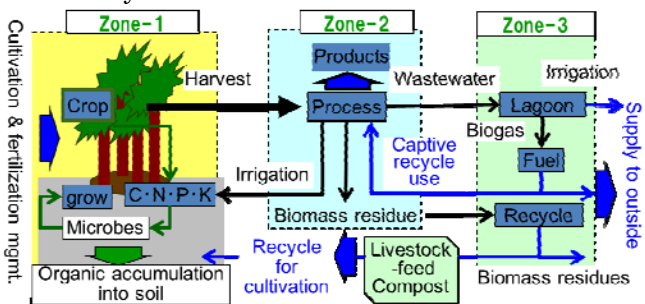


Fig.1 Plantation system incorporated with recycles of biomass residues for captive and external use.

Zone-2 shows processing and refining of crops from plantation such as sugarcane, oil palm, cassava, etc. Material flow of carbon, nitrogen, phosphorus and potassium, and thus energy flow are analyzed by the site observation. The data will

be used to diagnose the condition of processes.

Zone-3 shows the treatment and recycle of biomass residues and of wastewater such as composting, anaerobic digestion, production of livestock feed, power generation and so on. Material flow and energy flow in those systems are investigated in the plantations.

By using the results in Zone-1 ~ 3, system dynamic model will be developed to simulate the behavior of plantation system with recycle use of biomass residues toward sustainable production and for the reduction of environmental loading.

$$\frac{dC(t)}{dt} = S(t) - \{k \times f_T \times f_M \times f_C + f_{Till}\} \times C(t)$$

Applied Org-C    Soil temp    Cover crop    Organic-C in soil  
↑                    ↑                    ↑                    ↑  
Coefficient    Moisture    Till or no-till

Fig.2 Development of organic carbon degradation model based on modification Troth-C model.

#### 【Expected Research Achievements and Scientific Significance】

Appropriate management of soil and soil ecosystem for environmental conservation type agriculture with sustainable production of crops in plantations is proposed based on the analyses of material and energy flow and behavior of soil ecosystem in various plantations. Procedure to design of sound recycle system of biomass residues in and outside plantation can be developed.

#### 【Publications Relevant to the Project】

- H. Kamahara, U. Hasanudin, K. Fujie, et al., Improvement Potential for Net Energy Balance of BDF Derived from Palm Oil: A Case Study from Indonesian Practice, *BIOMASS AND BIOENERGY*, 34, 1818-1824(2010)
- M. Hanif, Y. Atsuta, K. Fujie, H. Daimon, Supercritical Fluid Extraction and UPLC of Respiratory Quinones for Microbial Community Analysis in Environmental and Biological Samples, *Molecules*, 17,2628-2642 (2012)

【Term of Project】 FY2013 - 2016

【Budget Allocation】 98,200 Thousand Yen

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