

Closed ecosystem experiments for disentangling material circulation in biosphere

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BACKGROUND: In 1994-99, Institute for Environmental Sciences (Rokkasho-mura, Aomori prefecture, Japan) installed Closed Ecosystem Experiment Facilities (CEEF), in which an ecosystem circulating materials without material exchange between inside and outside is constructed, in order to collect experimental data on transfer, circulation, and accumulation of materials for more realistic estimation of influence of gaseous radioactive elements which would be exhausted from the nuclear fuel reprocessing facilities on habitats than existing one. C-14 is one of important radio nuclides in waste gas from the reprocessing facilities, because contribution of C-14 to total dose by the waste to habitats was estimated to be around 35%. However, there is unsatisfactory data about transfer of C-14 especially for human so far.

OUTLINE OF CEEF PROJECT: In the CEEF, physical / chemical material circulation systems which are unique compared to other facilities were installed and improved, and technologies for plant cultivation, animal holding, habitation, and measurement of material flow were developed, in 2000-04. Closed habitation experiments, circulation of O₂ and CO₂, and supply of almost food from the plant system in the facilities started in 2005. Water circulation and waste material circulation are to be started in 2006 and 2007, respectively. Single duration of the habitation experiments was 1 week in 2005, and is to be elongated to 1 month, 2 months, and 4 months, in 2007, 2008, and 2009, respectively. In the CEEF project, using stable isotope C-13 as an analogue of radioactive C-14, transfer of the carbon from atmosphere through crops to livestock and human is to be investigated experimentally. Although carbon transfer in the ecosystem within the CEEF is indeed different from that in the real ecosystem, data which are to be obtained in the project is necessary for construction of more precise prediction models of C-14 transfer than existing models. Using these models with other data from outer source, more realistic dose prediction to habitats would be provided, because the models were derived from experiments using real human.

OUTLINE OF EXPERIMENT IN 2005: 1-week habitation experiments were conducted three times from September to November in 2005 using the CEEF. 2 human subjects (Eco-nauts), 2 Shiba goats, and 23 crops were incorporated in those experiments. In those experiments, oxygen necessary for human and animals were separated and supplied from crops' atmosphere, and CO₂ exhausted by human and animals were separated, transferred, and utilized for photosynthesis of the crops. Although rice grain, soybean seed, and peanut seed were supplied from outer source in the first experiment, almost foods for human and feeds for animals including rice and soybean were supplied from crops in the CEEF. In addition to recycling of transpired water from crops, waste nutrient solution from crops cultivation was filtered, adjusted by addition of depleted nutrients, and recycled. Data on carbon balance of crops, intake carbon of human and animals, whole expired CO₂ of human and animals were obtained for each day during those three 1-week periods.

CONSIDERATION ON UTILIZATION OF TECHNICAL OUTPUT FROM CEEF PROJECT: Before and just after the first closed habitation experiment in 2005, majority of mass media in Japan was interested in utilization of technical achievement of CEEF project leading to space mission. Right now, JAXA is reconstructing long term space development plan. Whether targets in the plan would include habitation on moon and Mars or not is not sure, and how extent the advanced life support systems technology would be propelled has not been decided. Therefore, direct contribution of technical output from CEEF project to human-in-space activities cannot be stated so far, because time range of our project is only next four years. But, it is necessary to maintain information exchange between CEEF and space oriented activities.