Risk and Benefit Analysis of Microbial Associated CO₂ Geological Storage

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Introduction

Among in-situ microbes within depleted oil-gas reservoir, there are special microbes those produce much more methane gas in CO₂ rich environment than in CO₂ poor environment. CO₂ acts as a catalyst in the reaction. If we maintain preferable conditions for methanogenesis archaea during geological CCS, we will be able to abate emission of GHG and produce natural gas as one of nal natural energy resources at the same time. We named the concept as Microbial associated Geological CCS (Bio-CCS) [1]. In Bio-CCS, CO₂ will be injected for two purposes: to abate GHG and to cultivate methanogenic geo-microbes. CH₄ gas will be produced later from other wells. The procedure is similar to the Enhanced Oil/Gas Recovery (EOR/EGR) operation, but in Bio-CCS, the target is production of methane out of depleted oil/gas reservoir during CO₂ abatement.

Methanogen in depleted reservoir

We examined relationship between reactions of in-situ microbial communities and CO₂ partial pressure in cultivation conditions. We collected bailed water samples those containing in-situ microbes from Yabase depleted oil-gas field in Japan. We kept containers in 50°C, 5MPa, and measured concentrations of CO₂ and CH₄ partial pressures of the gas in the containers. As the result, we found specific species that accelerates CH₄ production rate two times faster than other methanogenic species (1). The findings initiated the Bio-CCS concept.

Feasibility study of Bio-CCS

When we consider feasibility of Bio-CCS concept, the most essential information is CH₄ production potential. To estimate production rate, we assumed a procedure of Bio-CCS site: 1 million tons CO₂ will be injected into depleted oil reservoir in 10 years, the reservoir will be kept still for 90 years and 0.5 million CH₄ will be produced; after 100 years from the first CO₂ injection, CH₄ production will be started. We developed a basic geological model of Bio-CCS process on CHEM-TOUGH simulator, and implemented microbial activities and CCS process into it. We applied measured value in Nagaoka and Yabase as mineralogical properties of depleted reservoir. We assumed a fluid flow model: residual oil is a part of matrix and it will not move; fluid will flow in the rest, 0.1 real pore space. Then we estimated CH₄ production rates and other masses distributions (2). Given these conditions, estimated CH₄ production rates were about 1/10 ~ 1/100 of injected CO₂, after 100 years of first injection. Based on result of numerical calculations, we developed hazard scenarios by way of literature survey and statistical analysis of accident statistics. Then we applied the hazard scenarios to the assumed Bio-CCS procedure.

Results

As the result, the preliminary risk assessment assures that the Bio-CCS process will be safe. If happens any leaking accidents, most impacts on peripheral area of Bio-CCS site will be negligible. Refining the model for numerical simulation and Bio-CCS site evaluation system, we developed prototype of Microbial associated Geological CCS (Bio-CCS) site evaluation system.

References: