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Controlled release test facility to develop environmental monitoring techniques for geologically stored CO_2 in Korea

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Abstract

Two sets of controlled release test facility (EIT) were constructed in unsaturated and saturated zones by the Korea CO_2 Storage Environmental Management (K-COSEM) Research Center to develop efficient and accurate environmental monitoring techniques required for secure geologic carbon storage. The unsaturated zone EIT consists of a 51 m long horizontal well for artificial CO_2 leakage at the depth of 2.5 m below the land surface, a surface injection control system, and diverse monitoring devices. Following baseline surveys, a preliminary CO_2 release test was first performed for 4 days in October 2015, with the released amount of about 390 kg CO_2. The saturated zone EIT to develop efficient monitoring techniques in intermediate depths was constructed in the end of 2015. It consists of an injection well at the depth of 24 m and 8 multi-level monitoring wells. In 2016, long-term CO_2 release tests using EITs have been performed. The outlines of EITs of K-COSEM are summarized in this paper.

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Keywords: Geologic CO_2 storage; Environmental monitoring; Controlled release test; Near-surface ecosystems; Shallow groundwater; EIT

1. Introduction

Geologic storage of CO_2 is considered to be a promising technology to significantly mitigate CO_2 emission into the atmosphere. However, geologic CO_2 storage has some potential environmental risks due to the possibility of CO_2

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leakage through unexpected pathways, such as sealing deficiency, faults, and abandoned wells, among others. Thus, appropriate environmental management is crucial for secure CO_2 storage, which includes monitoring, evaluation, and prediction of the migration and leakage of stored CO_2. In particular, accurate and efficient monitoring techniques should be selected to be applied for a storage site, based on the site-specific, geologic, and hydrogeologic conditions.

Given that geologic CO_2 storage is targeting deep (> 800 m) permeable layers, it takes a very long time for stored CO_2 to leak to the surface. Therefore, it is difficult or impossible to monitor and evaluate the environmental impacts of CO_2 leakage from actual storage sites on the surface and near-surface ecosystems, such as soil and shallow aquifer. For these reasons, studies using the controlled CO_2 release test facility in shallow subsurface have been performed worldwide. The body of research using controlled CO_2 release tests (or experiments) can be divided into two types [1,2,3]: 1) studies aiming to understand both CO_2 migration through near-surface ecosystems and the associated environmental impacts of CO_2 leakage on soil, plants and microbes, and 2) studies seeking to understand CO_2 migration and its geochemical impacts on shallow aquifer. The sites of the former type include the ASGARD site in Nottingham, the UK [4,5], the Grimsrud Farm in Norway [6,7], the ZERT site in Montana, the US [8,9,10], the Ginninderra site in Australia [11], the PISCO2 site in Spain [12], and the Ressacada Farm in Brazil [13]. The research sites of the latter type include the Plant Daniel site and the Cranfield site in Mississippi, the US [14,15,16,17], the Brackenridge in Texas, the US [18,19], the Newark Basin site in New York, the US [20,21], the CO_2 Field Lab in Norway [22,23], the Vrøgum site in Denmark [24,25], the Wittstock site in Germany [26], and the Catenoy site and Lodeve site in France [27,28]. In the ZERT, the Ginninderra, and the Ressacada Farm sites, research for the two types was performed in parallel.

In 2014, the Korea CO_2 Storage Environmental Management (K-COSEM) Research Center has been inaugurated by the support from Ministry of Environment of Korea to perform multidisciplinary research on the environmental risk management of geologic carbon storage. To develop efficient and accurate tools to monitor CO_2 leakage through soil and groundwater and to assess the impacts of CO_2 leakage on the surface and near-surface ecosystems, the K-COSEM Research Center has constructed two sets of controlled CO_2 release test facility in unsaturated and saturated zones. The test facility was named EIT (Environment Impact Evaluation Test Facility on Seepage of Geologically Stored CO_2). For two years, 2014-2015, selection and characterization of the site, installation and preliminary operation of the unsaturated zone EIT, and installation of the saturated zone EIT were conducted. The EITs of K-COSEM Research Center are open to any institutions to collaborate for developing environmental monitoring technologies required for safe geologic CO_2 storage. In the present paper, backgrounds and outlines of EITs of K-COSEM Research Center are introduced.

2. Location and geologic/hydrogeologic backgrounds of the EIT site

2.1. Location

The EIT site is located in Eumseong, Chungcheongbuk-do province and is about 80 km away from Seoul (see Fig. 1). The access to the site is very easy due to its location near a highway. The test site with the total area of about 10,000 m^2 is situated on a small hillock area in the uppermost stream of Mihocheon, a primary tributary of the Geum River. The site has been used as a dry field that is surrounded by rice paddies.

2.2. Geological features

The area of the EIT site belongs to the western part of the Cretaceous Eumseong basin which was formed along the mid-western boundary of the Okcheon fold belt. Therefore, the regional geology is composed of Precambrian metamorphic rocks of the Gyeonggi Gneiss Complex in the west, Jurassic to Cretaceous granitoids intruding metamorphic rocks, Cretaceous fluvial sedimentary rocks on the east, and Quaternary alluviums, in ascending order [29]. Local geology of the test site comprises biotite granite of the Jurassic age.