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# Electrical resistivity imaging (ERI) monitoring for groundwater contamination in an uncontrolled landfill, South Korea

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A B S T R A C T

In the study area, uncontrolled landfill leachate is a serious cause of groundwater contamination that occurs extensively and rapidly following the rainy season. For this reason, the use of traditional hydrogeological monitoring methods using drilled wells is expensive and limited. Electrical resistivity imaging (ERI) is suitable for monitoring groundwater contamination because this method helps quickly investigate a large site without the need for well drilling. The resistivity of the landfill leachate is lower than that of clean groundwater; based on this fact, we evaluated the diffusion of landfill leachate before and after the rainy season using 3-D ERI characterization. In addition, ERI results were compared with piezometric and hydrochemical data obtained from observation wells for the purpose of cross-validation. The groundwater monitoring results agreed with the 2-D and 3-D interpretation of ERI results. The electrical resistivity values of contaminated zones were lower than those of clean zones due to an abundance of ions or molecules in the groundwater. The resistivity boundary between contaminated and clean zones observed in the inverted 2-D and 3-D ERI sections was considered to be approximately 100 Ω-m. The low-resistivity anomaly of the contamination zones increased in extent after rainfall. The expansion was likely accelerated by groundwater movement and diffusion of the landfill leachate. Images of the change in electrical resistivity were helpful for characterization of the behavior. The two-directional behaviors of NE-SW and N-S trends were confirmed by the 3-D ratio images. It is therefore, considered that the ERI technique is excellent for imaging contaminated zones as well as monitoring the behaviors of landfill leachate in uncontrolled landfills.



## 1. Introduction

Groundwater used for public-supply, agriculture, and industrial purposes can be contaminated as a result of various environmental problems. Amongst these, landfill leachate is a serious issue because of its continuous inflow into subsurface materials. The diffusion of landfill leachate is extensive and occurs quickly owing to an increase in groundwater flux following heavy rain. Hydrogeological monitoring is useful for characterizing contaminated sites and a variety of methods are available to measure groundwater contamination (Cherry et al., 1983). However, most of these methods are expensive and limited because of the requirement for observation wells.

Electrical resistivity imaging (ERI) has been applied to hydrogeological studies such as groundwater contamination survey (Benson et al., 1997) and salt-affected soil monitoring (Mas-Pla et al., 2013; Zarroca et al., 2014). Groundwater monitoring using this method is more efficient than traditional hydrogeological methods because there is no need for observation wells. This method utilizes the fact that the electrical resistivity (reciprocal of electrical conductivity) of landfill leachate is lower than that of clean groundwater. Small changes are detectable using this method because of high data resolution (Buselli and Lu, 2001; Hagrey and Petersen, 2011; Slater and Sandberg, 2000).

Two-dimensional (2-D) electrical and electromagnetic methods have been utilized for groundwater monitoring. However, it is known that more accurate and useful geological features are obtained from 3-D ERI results (Sasaki, 1994). Although there are case studies using the 2-D ERI for investigating groundwater contamination, 3-D ERI case studies are rare. Therefore, we attempted to characterize the movement of landfill leachate both before and during the rainy season by interpreting both 2-D and 3-D ERI results. For cross-validating our findings, the ERI monitoring results were compared with hydrogeological monitoring data obtained from the observation wells.

## 2. Site description

Satellite photography and locations of ERI monitoring lines and observation wells for the survey area are shown in Fig. 1. This landfill is located in Geumsan-gun, South Korea, and was constructed for

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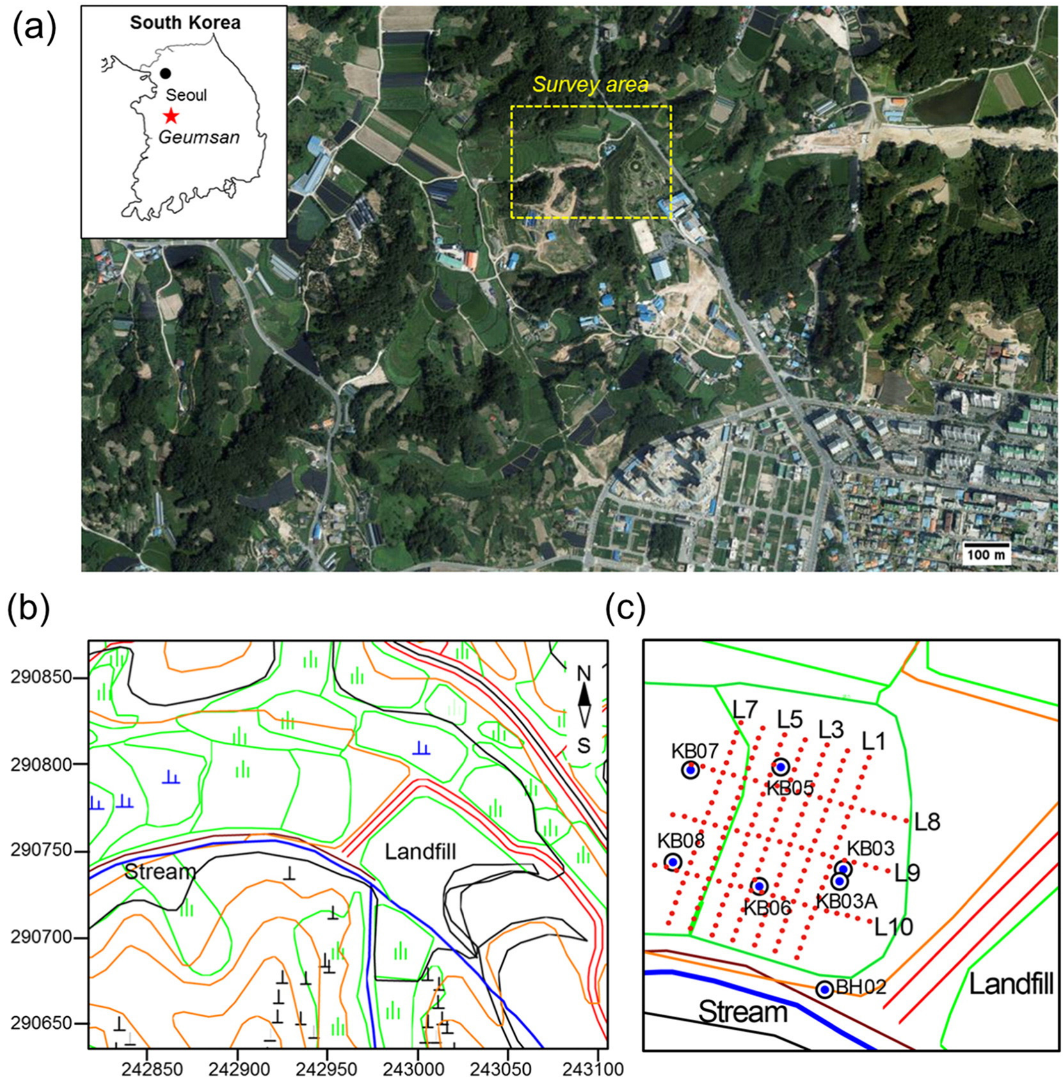


**Fig. 1.** Satellite image (a) and detailed site maps showing observation wells and ERI monitoring lines (b) and (c).

residential waste. No shield or barrier are installed at the site to prevent leachate in the landfill and only periodic pumping using drainage pipes has been conducted (Park et al., 2008). However, this treatment is not sufficient to prevent contamination. For these reasons, the landfill leachate had been continuously leaking to the subsurface aquifer and both aquifer and groundwater are contaminated. The contaminated

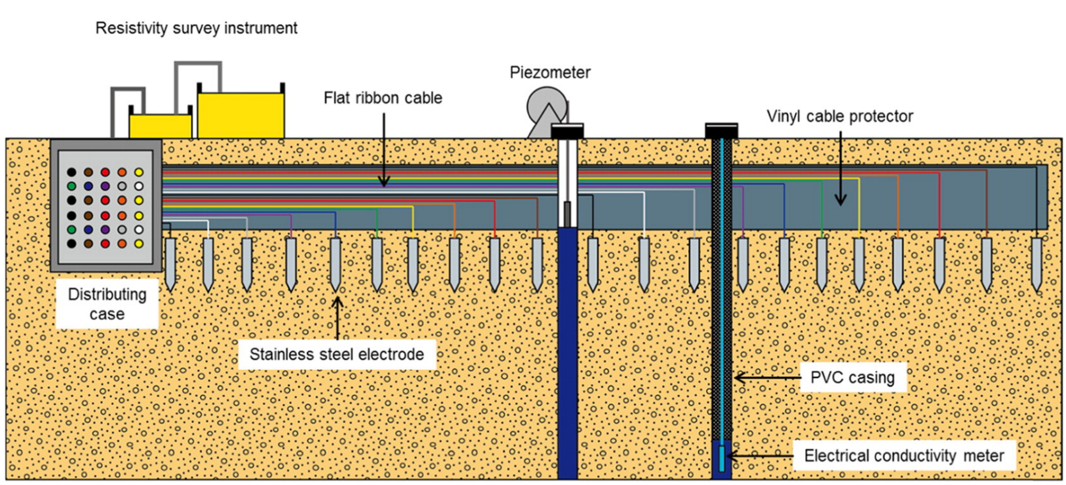


**Fig. 2.** Configuration of resistivity monitoring system for data acquisition of a monitoring line and two drilling holes measuring the water table and electrical conductivity for cross validation of resistivity monitoring results.