An Interpretation of Changes in Groundwater Level and Electrical Conductivity in Monitoring Wells in Jeju Island

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Abstract: Water sources in volcanic Jeju Island are almost entirely dependent on groundwater because there are actually no perennial streams or rivers due to the permeable nature of surface soils derived from basaltic or trachytic rocks. Uncontrolled development of groundwater resulted in substantial water-level decline, groundwater pollution, and seawater intrusion in several places of the island. To maintain its sustainable groundwater, the provincial government has declared some parts of the island as the Special Groundwater Conservation/Management Area since 1994. Hence, all the activities for the groundwater development in the area should obtain official permit from relevant authorities. Furthermore, to acquire information on groundwater status, a network of groundwater monitoring was established to cover most of the lowland and coastal areas with the installation of automatic monitoring systems since 2001. The analysis of the groundwater monitoring data indicated that the water levels had decreased at coastal area, especially in northern part of the island. Moreover, very high electrical conductivity (EC) levels and their increasing trends were observed in the eastern part, which was ascribable to seawater intrusion by intensive pumping in recent years. Water level decline and EC rise in the coastal area are expected to continue despite the present strict control on additional groundwater development.

Keywords: groundwater, basalt, Jeju Island, electrical conductivity, a network of groundwater monitoring

요약: 제주도의 지하수 관측망 자료를 이용한 지하수위 및 전기전도도 변화 해석

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Abstract: 제주도의 현무암과 조면암으로부터 기원한 투수성 높은 토양으로 인하여 지표수 유입에 따라 상시하천 발달이 어려워, 용수의 대부분을 지하수에 의존하고 있다. 이에 따른 무분별한 지하수 개발은 지하수위 강하로 이어져, 제주도 내 많은 지역에서 지하수 오염과 해수침투 현상이 나타나고 있다. 제주특별자치도는 제주도의 항구적인 지하수자원 보전을 위하여 1994년 이래 일부 지역에 지하수 보건구역으로 지정하였으며, 이 지역내의 모든 지하수 개발은 허가를 받도록 지정한 바 있다. 또한 지하수 수문과 관련된 수리지질 정보 획득을 위하여, 2001년 이래 제주도 내 해안지역 및 저지대 전체를 대상으로 지하수 관측망을 설치·운영 중이다. 본 연구에서 이러한 지하수 관측망으로부터 얻어진 지하수위, 수온, 전기전도도 등 장기 관측자료를 분석한 결과, 북부 해안지역의 경우 지하수위가 지속적으로 하강하는 것으로 나타났다. 또한 동부 해안지역의 경우는 최근 취수량의 급격한 증가에 따른 해수침투의 영향으로, 대부분의 관측 정에서 전기전도도가 높게 나타나며 지속적으로 증가하고 있는 추세로 분석되었다. 이러한 문제점들은 지하수 개발과 관련하여 제주특별자치도의 강력한 통제로 인하여 최근까지 감소하는 추세이지만, 본 연구 결과에 의하면 해안지역의 경우에는 지하수위 하강 및 전기전도도 상승 현상이 지속될 것으로 판단된다.

주요어: 지하수, 현무암, 제주도, 전기전도도, 지하수 관측망

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Introduction

Being 400 km distant from south of Seoul, the capital of Korea, the Jeju Island is the largest volcanic island in the country (Fig. 1a). The island is 73 km in length and 32 km in width. With the location of the Halla Mountain (1,950 m) in the center of the island, its topographic elevations exhibit a centric shape (Fig. 1b). In addition, the island is topographically steep in N-S direction, while it is relatively gentle in E-W direction. Ephemeral streams are mostly developed in N-S direction (Fig. 1c). The island is almost entirely dependent on groundwater as water source for various uses because there exist practically no perennial streams or rivers (Won et al., 2006). The streams run only in the wet season or in the heavy rain period. Rainfalls easily and rapidly infiltrate into the subsurface due to high permeability and large porosity of land surface originating from volcanic rocks.

Before 1994, groundwater was developed without any proper or administrative control, similar to the condition seen in the mainland of the country. Uncontrolled groundwater development resulted in various groundwater hazards such as substantial water-level decline, anthropogenic groundwater contamination, and seawater intrusion (Lee et al., 2007a). Especially in coastal areas, a large increase in salinity (or EC) of groundwaters led to the abandonment of many wells (Kim et al., 2003) and encroachment of the seawater (sulfuric water) has aggravated the conditions of water supply in the island. The “Groundwater Law” was enacted in 1994 to regulate the groundwater development and to establish the national plan of sustainable conservation of the groundwater resources throughout the country. Since then, the Jeju provincial government established an action plan consisting of groundwater monitoring and strict local regulations on the groundwater development.

Focusing on the coastal areas, where substantial seawater intrusion was observed, the local government declared them as the “Special Groundwater Conservation/Management Area”. According to this declaration,