HYDROGEOLOGICAL INVESTIGATION AND DISCHARGE CONTROL OF A NUTRIENT-RICH ACIDIC SOLUTION FROM A COASTAL PHOSPHOGYPSUM STACK AT YEOCHEON, KOREA

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Abstract. Nutrient-rich, highly acidic leachate draining from a coastal phosphogypsum storage site located at a phosphate fertilizer manufacturing company posed potentially harmful environmental effects to the coastal ecosystem. This study evaluated the chemical characteristics of the phosphogypsum and the hydrogeological characteristics of the surroundings. Hydraulic and chemical properties of the leachate draining from the site were also evaluated. The leachate is nutrient-rich and very acidic and discharges into the sea. The leachate and seawater are hydraulically connected through highly-permeable riprap placed at the toe of the stack. The chemical quality of the leachate and its drainage rate showed large variations depending on the location of the well, indicating heterogeneous hydraulic conditions. A vertical barrier system consisting of horizontal drainage wells and vertical leachate-collecting wells is suggested, in order to contain and collect the leachate. A back-up system of soil-bentonite cut-off walls is suggested to control leachate discharge to the sea.

Keywords: horizontal drain well, phosphate, phosphogypsum stack, seepage, tidal fluctuation

1. Introduction

Phosphogypsum is the major byproduct of the wet acid phosphorus production process and it is a major environmental concern in terms of disposal of the large volumes produced (Rutherford et al., 1996; FIPR, 1998; San Miguel et al., 2001). Phosphogypsum contains relatively high concentrations of trace metals, including heavy metals (Luther et al., 1993).

At Yeocheon, Korea, a phosphate fertilizer manufacturing company that generates each year about 1.44 \times 10^6 m^3 of phosphogypsum byproduct has been stacking wet phosphogypsum near the coastline since 1977 (Figure 1). The resulting effluent from this site has been a cause of public grievance since it was reported that a large amount of highly acidic water (leachate) containing various hazardous constituents has been leaking into the adjacent shore. This hazardous leachate is believed to threaten the biota of the near-shore area. The local administrative authority of this area issued a compulsory order for the fertilizer manufacturing company to manage the stack and to control the leachate so that it does not discharge to the near-shore seawater.
An investigation was initiated as a response to the leachate discharge to the near-shore seawater. To implement the best waste management strategies, there is a need to analyze and understand the stacking system, the production of leachate, and the physical processes leading to leachate discharge to the sea (Rutherford et al., 1996). This study was part of an integrated study to evaluate the impact of the highly acidic leachate on the environment of the shore, and to design a method for hydrodynamic containment of the acidic leachate. The objectives of this study are to investigate the hydrogeological characteristics and water quality in and around the phosphogypsum stack, and to identify some important factors controlling the water quality and hydrogeological characteristics of the phosphogypsum stack. Thus, this study was implemented to suggest an engineering design for the control and containment of the leachate discharge from the phosphogypsum stack.

2. Materials and Methods

2.1. SITE CHARACTERISTICS AND HYDROGEOLOGY

The study site is located on the southern coastal area of the Korean peninsula (Figure 1). The fertilizer manufacturing company has been located at this site since 1977 and is still in operation. This company produces 300,000 tons of phosphate...