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Contamination of a karstic aquifer by leachates from a urban solid waste landfill

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RESUMEN

Se ha controlado la contaminación producida por el lixiviado del vertedero de residuos sólidos de La Mina en el acuífero carbonatado (kárstico) del sistema de Marbella (sur de España). Se pueden diferenciar dos grupos de aguas contaminadas según su comportamiento hidroquímico: (1) la contaminación en los piezómetros, medida como Cl^- y conductividad eléctrica, se incrementa con el tiempo, y está asociada con precipitación de minerales carbonatados, evidenciada por la disminución en el tiempo de HCO_3^-, Ca^{2+} y Mg^{2+}; (2) en puntos cercanos al vertedero, la contaminación también se incrementa, pero el CO_2 del vertedero produce disolución adicional de minerales carbonatados, proceso que se ve reflejado en las altas concentraciones de HCO_3^-, Ca^{2+} y Mg^{2+}. La distribución de los puntos contaminados es irregular, aspecto que también se observa en los valores del porcentaje de mezcla de lixiviado, deducidos a partir de la modelización hidroquímica realizada. El punto más alejado al vertedero presenta la mayor afección (23'6 % de lixiviado), mientras que no se observan procesos contaminantes en el piezómetro más cercano. La heterogeneidad del medio kárstico, con diferentes tipos de almacenamientos (conductos, fracturas/fisuras y matriz) y una diferencia de densidad entre el lixiviado y el agua no contaminada deben regir este comportamiento.

Palabras clave: acuífero kárstico, groundwater contamination, lixiviado, sur de España, vertedero de residuos sólidos

ABSTRACT

The contamination of a karstic aquifer by the leachate from the urban solid waste landfill at La Mina (Marbella, S Spain) have been monitored. Two hydrochemical behaviours at the contaminated points are observed: (1) contamination at the piezometers, measured as Cl^- and electrical conductivity, increase over time and it is associated with precipitation of carbonate minerals, evidenced by a reduction in the concentration of HCO_3^-, Ca^{2+} and Mg^{2+}; (2) at points near the landfill, contamination also increase, but CO_2 from the landfill provokes an additional dissolution of carbonate minerals, a process reflected in the high concentrations of HCO_3^-, Ca^{2+} and Mg^{2+}. The distribution of the contaminated points were irregular, also seen in the percentage values of leachate mixing, deduced with the hydrochemical modelization between leachate and karstic waters. The most distant piezometer presents the greatest impact (23'6% of leachate), whereas no traces of contamination were detected at one piezometer close to the landfill. The heterogeneity of the karstic media, with different types of storage (conduits, fractures/fissures and matrix) and a difference in density between the leachate and the groundwater must drive this uncommon distributionof contaminants.

Key words: groundwater contamination, karstic aquifer, leachate, southern Spain, urban solid waste landfill

1. INTRODUCTION

The pollution of underground water by leachate of Urban Solid Waste Landfills (USWL) has been studied by many researchers (Baedecker and Back, 1979; Cherry, 1983; Christensen *et al.*, 1994) but most of the cases in homogeneous terrain. The study of the same processes in karstic aquifers reveals the problem of its heterogeneity and, consequently, the difficulty of locating and controlling the contaminants in the aquifer. The concentration and migration of contaminants in a karstic aquifer depends on the storage properties in each zone affected by the contamination (Almeida *et al.*, 1995) therefore, it is necessary a detailed analysis of the flow in a karstic aquifer with its additional difficulties, such as an accurate recognition of the often random internal structure, i.e.: distribution of transmissive elements.

In this article, we present the results obtained in a karstic aquifer in southern Spain affected by the leachate of the urban solid waste landfill of La Mina landfill (fig. 1).

Waste dumping began in the landfill in early 1975 and continued until its closure in December 1999. The average thickness of the waste was 12 m and it had an area of 54,250 m^2, giving a total volume of nearly 650,000 m^3. Most of the waste was of urban origin, such as organic matter, paper, glass, plastic, wood and building materials. The landfill is unlined, so some fraction of the leachate infiltrated the Marbella carbonate aquifer (Vadillo *et al.*, 1999a and b, 2000). The leachate presented an average electrical conductivity (EC) of 22,184 µS/cm, with a minimum of 10,430 µS/cm on rainy days and a maximum of 40,900 µS/cm during very dry periods. Chloride and bicarbonate are the main anions