NITRATE CONTAMINATION OF GROUNDWATER BY AGRICULTURAL ACTIVITIES IN THE PROTECTED AREA OF COSTA DA CAPARICA (PORTUGAL)

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Resumo - Esta pesquisa compreendeu uma investigação da contaminação por nitratos (NO_3^-) em um aqüífero costeiro numa area de 220 ha localizada nas Terras da Costa de Caparica, município de Almada, Portugal. O estudo se baseou em resultados analíticos e propriedades do aqüífero obtidos em duas estações climáticas distintas no ano de 2010. Quatro áreas com concentrações de NO_3^- acima de 300 $mg.L^{-1}$ foram identificadas em ambas campanhas de amostragem, demonstrando uma correlação direta com as práticas agrícolas observadas na região. Concluiu-se que as águas subterrâneas encontram-se contaminadas, chegando a apresentar concentrações acima de 50$mg.L^{-1}$ em até 77% dos poços amostrados, conforme resultados da campanha realizada na estação seca (verão).

Abstract - This study comprised of an investigation of the nitrate (NO_3^-) contamination in a coastal aquifer within an area of 220 ha called Terras da Costa, an agricultural region spread along the Costa de Caparica, Almada municipality, Portugal. It was based on analytical results and aquifer hydraulic data collected in two sampling events (summer and winter) occurred in 2010. Four areas with NO_3^- concentrations in groundwater above 300 $mg.L^{-1}$ were identified in both seasons, demonstrating direct correlation with agricultural practices observed in the region. Based on the results, groundwater was confirmed to be contaminated with concentrations above 50 $mg.L^{-1}$ in up to 77% of the sampled wells during the dry season (summer).

Keywords: coastal aquifer, groundwater, nitrate contamination, agriculture.

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1 - INTRODUCTION

Terras da Costa are part of the Costa de Caparica parish, Almada municipality, Portugal. It comprises a plain region within the Protected Landscape called 'Arriba Fossil', located southern of Lisbon, on the north portion of Setubal peninsula. The region is an important touristic destination in the Lisbon metropolitan area and is also occupied by small agriculture properties, mainly used for intensive irrigation horticulture. This practice is possible due to the favorable climate conditions and groundwater availability. However, the continuous use of the soil in the Terras da Costa for cropping activities has caused an overloading of nutrients and also demanded high volumes of groundwater from the shallow aquifer for irrigation and sporadic human intake (Simões, 2004) [1]. Among the nutrients applied in the area to increase the productivity there are ammonium nitrate fertilizers. It is known that nitrate contamination in water causes serious adverse effects to both human and animals' health when ingested. For drinking water the maximum concentration of 50 $mg.L^{-1}$ of nitrates (as NO_3^-) is acceptable, according to the World Health Organization (WHO, 2008) [2]. In the agricultural area of Terras da Costa there is no water supply and groundwater is an important resource for the population. The objective of this study was to investigate the extent and level of contamination by nitrates in the shallow coastal aquifer. Also intended to assess the variability of nitrate concentrations at the end of the wet (winter) and dry (summer) seasons, due changes in agricultural practices and recharge rates. The region of interest corresponds to a strip land located along the Costa de Caparica shoreline with approximately 220 ha (**Figure 1**).

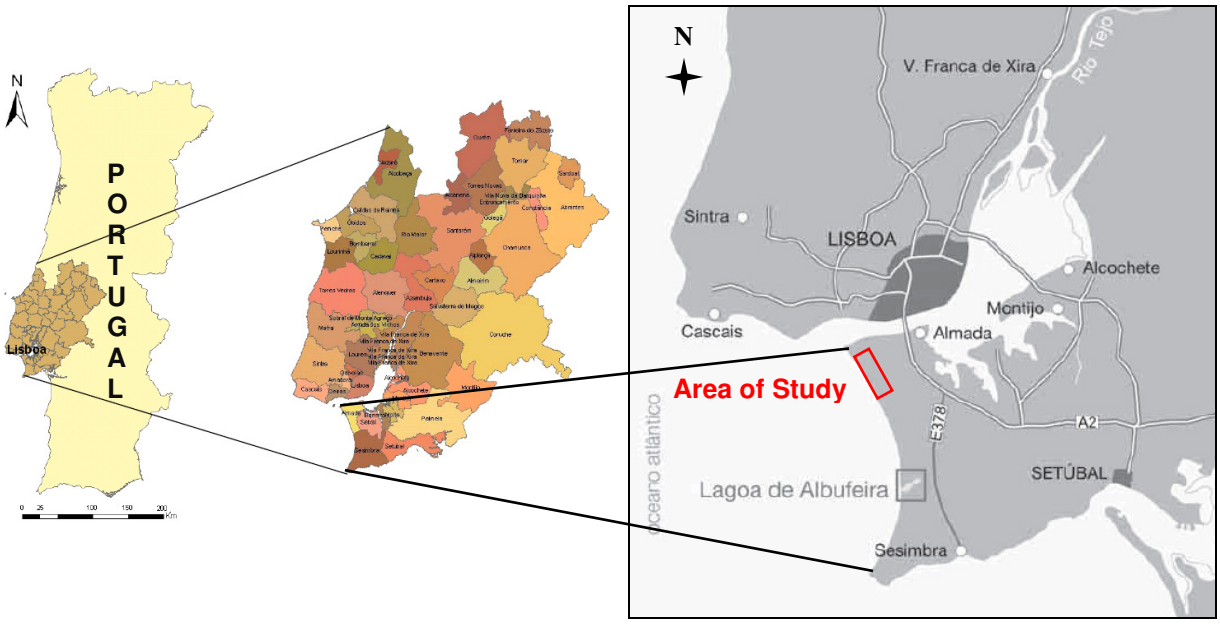

Figure 1. Area of study. Modified from Freitas and Ferreira (2004) [3].

2 - METHODS

The research consisted mainly of a combination of interpretation of field data and analytical results of samples collected from extraction wells at the region of study in two different sampling events occurred in 2010. A total of 26 samples were obtained in March of 2010 (winter) and analyzed for physical-chemical parameters, major anions (including NO_3^- and NO_2^-), major cations and alkalinity. In August 2010 (summer), 40 groundwater samples were analyzed for major anions and physical-chemical parameters, 25 soil samples were collected and analyzed for grain size and a field questionnaire was applied to the local farmers in order to obtain information about rates and frequency of fertilizer application, pumping rates and groundwater usage. Wells' construction details and hydrogeological parameters of the shallow aquifer were also gathered during the second sampling event. Soil samples were submitted for sieve analysis in the Environmental Geotechnical Laboratory of the National Civil Engineering Laboratory (LNEC) in Lisbon. All groundwater samples were analyzed in the laboratory of the Department of Earth Science, New University of Lisbon, according to the methodology described by Simões (2008) [4]. Iso-concentration maps of nitrate and other physical-chemical parameters were created along with a groundwater flow map which allowed the identification of the main potential sources of contamination, receptors and discharge areas.

3 - RESULTS

The shallow aquifer in the region of study is comprised by a fine to medium sand package with maximum thickness of 20 m, which was assumed to be regionally homogeneous and isotropic. The permeability coefficient was estimated in 3.94×10^{-3} cm.s^{-1}. The average groundwater depth during the summer was 5.4 m below ground level. The distribution of NO_3^- in groundwater during the two sampling events has shown four evident areas with high concentrations (above 300mg.L^{-1}) which matches with the agricultural practices of intense fertilizer application observed during the fieldworks.

The maximum concentrations of NO_3^- detected during the winter and summer were 682 mg.L^{-1} and 591 mg.L^{-1}, respectively. The shape of the NO_3^- iso-concentration maps and the position of the hot spots of NO_3^- concentration identified in the shallow aquifer were similar when comparing results of the two seasons. The hot spots were directly

correlated to the agricultural practices observed during the field inspections, represented by an uncontrolled application of inorganic fertilizers. Reductions in concentration with rates above 50% were identified in eight out of 21 wells comparing results from the wet and dry seasons.

4 - CONCLUSIONS

The type of sediments (mainly fine to medium sands with high permeability), plane topography and shallow depth of the groundwater associated with intense agricultural practices resulted in a high vulnerability to contamination of the shallow coastal aquifer in the region of study. Based on the results in two sampling events, groundwater was confirmed to be contaminated with concentrations above 50 $mg.L^{-1}$ in 70% and 77% of the sampled wells during the wet and dry seasons, respectively. The maximum concentrations of NO_3^- detected during the winter and summer were 682 $mg.L^{-1}$ and 591 $mg.L^{-1}$, respectively. The adoption of good agriculture practices is recommended for the region as part of a groundwater management strategy to reduce the risks to the community health and to allow the sustainable development of the Terras da Costa de Caparica.

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