STRATEGIES FOR NITRATE REDUCTION IN A CONTAMINATED COASTAL AQUIFER BY AGRICULTURAL PRACTICES CAPARICA, PORTUGAL

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Resumo – Esta pesquisa compreendeu uma análise da aplicabilidade de tecnologias de remediação para a redução de concentrações de nitratos (NO_3^-) em águas subterrâneas de um aqüífero costeiro na região das Terras da Costa de Caparica, Portugal. Uma área piloto foi selecionada com base em nove critérios para se avaliar a aplicabilidade das seguintes tecnologias de remediação *in situ*: Fitorremediação, Barreira Permeável Reativa e Biodenitrificação Estimulada *In Situ*. Vantagens e desvantagens de cada tecnologia foram analisadas e apresentadas em uma matriz para basear a proposição de futuros ensaios de campo. Concluiu-se que não há fatores de order técnica ou prática que impeçam a aplicação de qualquer uma das tecnologias estudadas na área piloto.

Abstract – This research compared the applicability of remediation technologies to reduce nitrates in groundwater in a coastal aquifer at Terras da Costa de Caparica, Portugal.

The purpose of the study was to select a pilot area in Terras da Costa in order to assess the applicability of the following in situ remediation technologies: Fitoremediation, Permeable Reactive Barrier and Enhanced In Situ Biodenitrification. Advantages and disadvantages of each technology were discussed and presented in a comparison matrix for decision and proposal of future pilot tests. It was concluded that no technical or practical factors would impede the application of the above technologies in the pilot area.

Keywords: nitrate contamination, fitoremediation, biodenitrification, reactive barrier.

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1 - INTRODUCTION

Nitrate contamination in water causes serious adverse effects to both human and animals' health when ingested. Infants are the most vulnerable. Blue Baby Syndrome is potentially fatal to infants under 6 months of age who ingest water contaminated by nitrates. The concentration of 50 mg. L^{-1} (as NO_3^-) is the maximum acceptable in drinking water according to the World Health Organization (WHO, 2008) [1].

The intense use of the soil at Terras da Costa, Concelho de Almada, Portugal for farming practices has caused an overload of nutrients and extraction of high volumes of groundwater from the shallow aquifer for irrigation. Martinez (2010) [2] demonstrated that 77% of 40 samples collected in August 2010 from existing wells at the region had concentration of NO_3^- above 50 mg. L^{-1}. According to that study, there is no public water supply at the majority of the properties and groundwater is also used in domestic activities.

The objective of this research was to undertake a qualitative assessment of the applicability of three in situ remediation technologies at a selected pilot area to reduce the concentrations of NO_3^- in groundwater to acceptable levels (50 mg/L^{-1}). The region of interest corresponds to a strip portion of land located along the Caparica shoreline, covering an average area of 200 ha, mainly occupied by small farms and summer houses.

This study is a research in progress aiming to undertake future field trials and a quantitative feasibility analysis for implementing one remediation technology at the pilot area, to be selected based on the results of this initial qualitative assessment.

2 - METHODOLOGY

Two major steps were followed in this research: the selection of the pilot area and the qualitative assessment of the applicability of three in situ remediation technologies at the selected pilot area, using a comparison matrix.

A list of nine criterions was developed to identify the pilot area which was found representative of the studied region to propose the implementation of future remediation field trials. The criterion included level and extent of the NO_3^- contamination, local agricultural practices with absence of current sources of contamination at the site, geochemical and hydraulic properties of the shallow aquifer as well as administrative issues, such as the requirement of reducing NO_3^- levels in groundwater in medium term.

A comparison matrix was created to identify main advantages and disadvantages of each of the following remediation technologies at the pilot area: Fitoremediation, Permeable Reactive Barrier (PRB) and Enhanced In Situ Biodenitrification. Basic requirements for implementing each technology were assessed against qualitative and basic aquifer properties (depth, permeability coefficient, gradient) and contamination levels at the pilot area to identify the main pros and cons of each technology.

3 - RESULTS

Based on nine criteria the property selected for proposition of future pilot feasibility trials corresponds to “Projecto 270”. This is a parcel of land between two highly vegetated areas located up and downgradient, according to the regional groundwater flow (**Figure 1**). The property owner adopts agricultural organic practices, making no use of fertilizers or pesticides, warranting the absence of sources of contamination at the site.

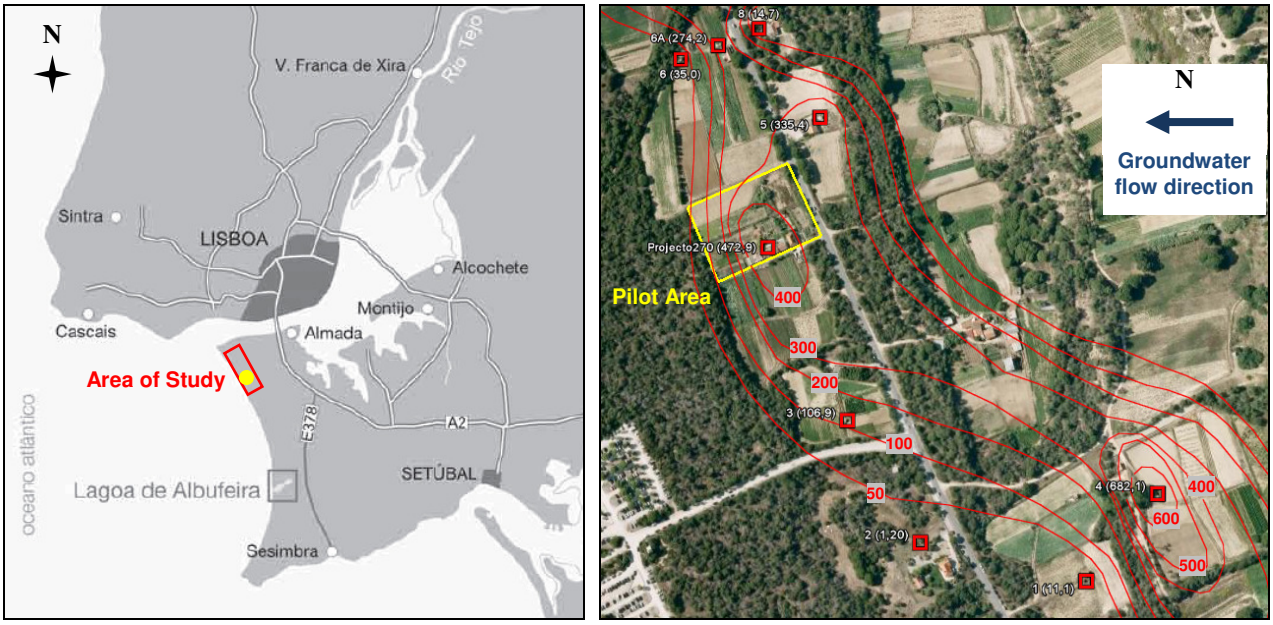

Figure 1. Area of Study highlighted in red (left) and Pilot Area highlighted in yellow (right). Nitrate (NO_3^-) iso-concentration values in $mg.L^{-1}$. Modified from Martinez (2010) [2].

Based on a qualitative analysis comparing the basic required conditions for implementing each of the three assessed technologies at the Pilot Area, Permeable Reactive Barrier has demonstrated to be the most feasible taking in consideration the estimated aquifer hydraulic properties and administrative factors, such as costs and timeframe. Fitoremediation is likely to have more limitations due to the level of

contamination and to possible presence of pesticides and metals (unknown) in groundwater which might be toxic to the plant in certain stages of growth. However the local climate conditions, depth to groundwater and gradient are expected to be favorable factors for the implementation of such technology, using species like hybrid poplar, already proved to be efficient in the reduction of NO_3^- in groundwater. Enhanced in situ biodenitrification using liquid carbon sources has also shown to be an adequate technology for the pilot area, while has possible high cost limitations requiring infrastructure for liquid storage, distribution, construction of injection wells and monitoring.

4 - CONCLUSIONS

Based on the qualitative comparison of the three remediation technologies and their possible interactions with site specific properties (hydrogeology, geochemistry and level of contamination), it has been concluded that no technical or practical limitations would impede the application of one or a consortium of three technologies at the pilot area, aiming the reduction of NO_3^- concentration to acceptable levels (50 mg. L^{-1}).

The application of one or a combination of more technologies, after their feasibility being confirmed by field trials, along with the adoption of agricultural good practices as per Directive 91/676/CEE [3] are considered a feasible way of seeking the sustainable development of the Terras da Costa.

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