



HAL
open science

Microbial and electrochemical synergy for sustainable groundwater remediation: combining pyrite-based denitrification and electrochlorination

Eleftheria Ntagia, Piet Lens

► To cite this version:

Eleftheria Ntagia, Piet Lens. Microbial and electrochemical synergy for sustainable groundwater remediation: combining pyrite-based denitrification and electrochlorination. 10th Conference of Mikrobiokosmos 2023, Nov 2023, Larissa, Greece. hal-04482774

HAL Id: hal-04482774

<https://hal.science/hal-04482774>

Submitted on 28 Feb 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Microbial and electrochemical synergy for sustainable groundwater remediation: combining pyrite-based denitrification and electrochlorination

Eleftheria Ntagia^{1,2} and Piet Lens²

¹ Université Paris-Saclay, INRAE, PROSE, 92160, Antony, France

² National University of Ireland, Galway, University Road, H91 TK33, Galway, Ireland

Keywords: groundwater, pyrite, nitrate pollution, coliforms, electrochemical disinfection

Groundwater constitutes more than 97% of the planet's freshwaters and serves above 30% of domestic needs. Poor sanitation facilities, release of untreated wastewater, cattle farming and intense fertilising activities are the main drivers of anthropogenic groundwater pollution, designated by increased concentrations of nitrate (NO_3^-), chloride (Cl^-) and coliform bacteria. Human exposure to pathogens and $>50 \text{ mg NO}_3^-/\text{L}$ in potable water has been linked to water-borne diseases and respiratory health issues¹. Furthermore, the current water treatment methods suffer from intensive chemical dosing and are therefore unsustainable in resource-limited environments.

This study combined autotrophic denitrification with FeS_2 as electron donor and electrochemical disinfection through Cl^- oxidation to Cl_2 ($\text{HOCl} + \text{OCl}^-$) to treat NO_3^- and microbial contamination and simultaneously benefit from the high Cl^- content of the polluted groundwater. Aim was to propose a potentially more sustainable and of reduced chemical input groundwater treatment approach.

A fluidized, FeS_2 (120 g) bed reactor was constructed in a 1 L glass column and operated, first in batch and then in continuous mode (18 h HRT) at $22 (\pm 2)^\circ \text{C}$, to denitrify polluted groundwater from a private well in Co. Galway, Ireland. The denitrified effluent was subsequently disinfected in a membrane divided electrolysis cell, with a Pt/Ti anode (25 cm^2), where Cl_2 was produced. The cell was operated in batch at 50 – 150 mA and the production of free chlorine, as well as the removal of total coliforms in relation to the electrolysis time and the current input were monitored.

During the 35 days of continuous denitrification, NO_3^- was removed with a consistent 79% NO_3^- efficiency from an initial $178 \text{ mg NO}_3^-/\text{L}$, at an average denitrification rate of $171 \text{ mg NO}_3^-/\text{L d}$. The electrochemical unit achieved a 4.5-log decrease in total coliforms at a minimum 41.7 Ah/m^3 charge density. The potable water limit of $\text{NO}_3^- < 50 \text{ mg/L}$ and 0 CFU/100 mL coliforms, was achieved without additional input of chemicals other than the initial FeS_2 addition in the denitrification reactor.

¹ Masindi, V. & Foteinis, S. Groundwater contamination in sub-Saharan Africa: Implications for groundwater protection in developing countries. *Clean. Eng. Technol.* **2**, 100038 (2021).