Bench Tests for Evaluation of Nitrate Reduction in Soil and Groundwater from a Brazilian Nitrogen Fertilizer Plant

Igor J.S. Mello (igor.mello@cpeanet.com), Flavia Belloni (flavia.belloni@cpeanet.com),
Daniel H. Teixeira (daniel.teixeira@cpeanet.com),
Sergio Crepaldi (sergio.crepaldi@cpeanet.com), and
Cristina Gonçalves (cristina.goncalves@cpeanet.com) (CPEA, São Paulo, SP, Brazil)
Edgar Leite (edgar.leite@yara.com) (Yara Brazil)

Contamination of soil and groundwater by nitrate is one of the main environmental liabilities in a Brazilian nitrogen fertilizer plant, where the plume achieves a water body. Previous bacterial DNA analysis in soil samples from the site showed that *Pseudomonas* is the most representative group indicating that biostimulation of denitrifying bacteria is an alternative to decrease plume extension by promoting chemical reduction of nitrate. Laboratory bench tests were carried out during four days with different substracts obtaining an efficiency of 99-100% of nitrate reduction in soil and groundwater after applying corn starch.
Biostimulation bench tests were carried out with soil and groundwater samples collected from a nitrogen-containing fertilizer plant located in Sao Paulo State, Brazil. Sampling methodology was in accordance with Brazilian directives.
Samples were initially analyzed for the electron acceptor substances commonly present in environmental samples from fertilizer sites, which could compete with nitrate for chemical reduction: dissolved oxygen (groundwater only), manganese, iron and sulfate. Additionally, concentration of nitrite, ammonia and total Kjeldahl nitrogen was also determined. Aiming the evaluation of bacterial development during the test, counting and DNA analysis were also performed.

Dextrose, barley, corn starch and potato starch were selected as substracts to be kept in contact with soil and groundwater samples with around 130 mg $N\text{-}NO_3$/kg and 163 mg $N\text{-}NO_3$/L respectively. After four days, high efficiency was observed only for corn starch (99%). Heterotrophic bacteria counting showed a significant increasing in soil (from 350 CFU/mg to 7,200,000 CFU/mg), being *Pseudomonas* the main representative group
Additional tests were performed to establish the optimum corn starch concentration. After evaluating a soil mixture of 2, 5,10 and 20%, it was observed that 2% was sufficient to observe chemical reduction of nitrate, considering its levels in the samples tested.
Despite the positive results for chemical reduction, soil permeability was considerably decreased when the starch/soil is in contact with groundwater. A mixture with a clay mineral commonly used in fertilizer plants (attapulgite) was evaluated, which proved to be suitable for soil permeability maintenance.

The tests showed that a mixture of 10:1 corn starch: attapulgite is a promising substrate for nitrate bioremediation to the studied site, due to increasing of local heterotrophic bacteria, with subsequent electron donation to the environment and nitrate mass reduction.
Corn starch at 2% has shown to be efficient for nitrate chemical reduction. However, due to the low soil permeability promoted by this substract, it is required a deflocculant such as starch / attapulgite.

Bacterial DNA analysis indicated the main presence of denitrifiers (Pseudomona).
From the financial point of view, biostimulation with corn starch is more attractive than bioaugmentation once it is avoided addition of representative number of foreign bacteria to the environment in order to to verify meaningful results.