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A MULTIVARIATE STATISTICAL ANALYSIS OF THE PERFORMANCE OF FLUIDIZED BED BIOREACTORS USED FOR *AD SITU* REMEDIATION OF WATER POLLUTED WITH PCE

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Abstract

The PCE biotic treatment is generally carried out in anaerobic conditions. On the other hand, use of zero-valent iron (ZVI) for the remediation of organic aliphatic chlorinated compounds has been successfully demonstrated. The use of hybrid systems, biological-ZVI reactors in the context of bioremediation of waters polluted with PCE seems to be a logical extension. Multivariate statistical analysis is increasingly used for processing results due to its capacity for handling and organizing massive quantity of data. This study uses principal component analysis (PCA) to identify the most relevant variables associated to the performance of fluidized bed bioreactors (FBBRs) operated in three electron acceptors modes for the depuration of a water contaminated with PCE.

Four lab scale, mesophilic FBBRs were implemented and fed a water that contained 80 mg PCE/L. In Period 1 two FBBRs were operated in methanogenic denitrifying (MD) regime and two as partially-aerated methanogenic (PAM). One MD and one PAM FBBR were coupled to a side sand-ZVI filter (MD-Z and PAM-Z). Bioreactor consortia at the start of Period 1 were unacclimated to PCE. In Period 2 all FBBRs were switched to methanogenic regime M. PCR-TGGE analysis was carried out as described elsewhere.

In general, switching from two electron acceptors mode to M regime significantly improved the dehalogenation efficiency in all bioreactors ($p < 0.0001$). FBBRs coupled to ZVI generally showed the highest dehalogenation efficiency (21-60 %). Regarding the PCA, the first three PC explained 93% of the variance of experimental data; the analysis succeeded in reducing the number of variables from 41 to 3. The first principal component (PC1) explained *ca.* 58% of the variance; it was associated with PCE metabolites in bioparticles and biogas trap as well as TKN-biomass and TGGE bands. The PC2 explained *ca*. 23 % of the variance and was associated with COD and PCE removal efficiencies (η_{COD}, η_{PCE}), dehalogenation efficiency ($\eta_{dehalog}$), ΔCl, and specific oxygen uptake rate (SOUR). Fig. 1a revealed three groups of variables (or ellipses ε), i.e., ε1: η_{COD}, η_{PCE}, $\eta_{dehalog}$, ΔCl; ε2: CV in biogas trap, PCE and CV in bioparticles and specific methanogenic activity. ε3: biomass-TKN, TGGE bands, and PCE metabolites.

PC1 represents the overall biotic activity in FBBRs. Regarding biological activities, the SDA was the metabolic activity nearest to PC1, and the highest specific activity in all FBBRs in the two periods. PC2 may represent the FBBRs aerobic activity since the SOUR is the nearest metabolic activity to the η_{PCE}, $\eta_{dehalog}$ and ΔCl. This suggests that the SOUR is a significant dehalogenation biotic activity in selected FBBRs. Bioreactors can be grouped in three clusters that are linked to their PCE removal efficiency and other secondary features (Fig. 2b); Group 1: M-Z and M (η_{PCE} 90.5 %, $\eta_{dehalog}$ 15.5 %), Group 2: MD-Z and MD (η_{PCE} 92.5 %, $\eta_{dehalog}$ 20 %), and Group 3: PAM bioreactors. This is consistent with and summarizes the performance improvement of methanogenic operation with coupled ZVI filter as reported above.

Key words: ad situ remediation, fluidized bed bioreactor, perchloroethylene, principal component analysis