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Remediation of PAH-Contaminated Soils: Experimental Analysis and Modeling of Hydrodynamics and Mass Transfer in a Soil-Slurry Bioreactor

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Extended Abstract

Polycyclic Aromatic Hydrocarbon (PAHs)-contaminated soils are a great environmental and public health concern nowadays. Their remediation is an important field of research as several remediation techniques have been developed with the purpose of removing PAHs from soil. However, further researches are necessary to develop environmental friendly biotechnologies that allows public and private sectors to implement efficient and adaptable treatments for contaminated soils. Aerobic soil-slurry bioreactor technology has emerged as one of these technologies with high potential as an effective and feasible treatment technic for PAH-contaminated soils. For this treatment, soil is excavated, conditioned and loaded into an aerated aqueous bioreactor. Then, mechanical and/or pneumatic mixing maintains aerobic conditions and homogeneity. Furthermore, air supply and mixing represent the most energy intensive units [1].

Although, extensive research has been done on this topic, mechanisms involved in the removal of PAHs from soil are still not completely understood. In addition to the biological processes involved, important mass transfer mechanisms need to be considered (oxygen gas-liquid mass transfer, adsorption-desorption, volatilization of PAH, etc.). In general, even for volatile PAHs, volatilization is not considered in the studies whereas, in some conditions (high aeration rate), it can be a major mechanism of "PAH removal".

The soil composition and concentration in the reactor should influence strongly the fluid viscosity, which is a key parameter governing the hydrodynamics and thus the mass transfer phenomena. Therefore, the aeration and mixing optimization requires a fine understanding of how different operational parameters influence the mixing and mass transfer mechanisms involved in the removal of PAHs from soil [2].

In this study, the influence of soil content (composition and concentrations) and operating conditions (air superficial velocity, stirring rate, etc.) on the mixing (rheology, etc.) and mass transfer phenomena (gas-liquid, adsorption-desorption) is addressed.

Experiments are performed in a glass standard bioreactor designed to control hydrodynamic conditions and temperature. Air is injected from the bottom through a porous glass sparger. Mechanical agitation is performed by a marine propeller connected to a motor. Hydrodynamic parameters are monitored in order to study their influence on the process and, particularly on the oxygen and PAH transfer phenomena. Rheological behavior of soil/water matrix has been measured with a capillary rheometer [3].

The oxygen transfer tests showed that for a given air superficial velocity and stirring rate, the oxygen transfer coefficient in soil/water matrix is reduced in comparison with clean water results. This decrease depends on the soil composition and was more pronounced with an increase in the soil content. Moreover, the soil/water matrix could be assimilated to a non-Newtonian fluid with shear-thinning behavior (mainly pronounced for high soil content). The impacts of solids concentration and its composition (soil mass and organic matter content in the soil) and operating conditions (air flow and stirring rate) on apparent viscosity, oxygen transfer and PAH volatilization will be modeled using experimental data.

***Keywords*:** Hydrodynamics, gas-liquid transfer, polycyclic aromatic hydrocarbons removal, slurry bioreactor, soil remediation.

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