EFFECTS OF SOLUTION AND SOIL CHEMISTRY ON THE DISTRIBUTION OF OIL RESIDUAL IN PATAGONIAN SOIL

S. M. RÍOS‡, N. S. NUDELMAN† and O. KATUSICH‡

†Department of Chemistry, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, 1428 Buenos Aires, Argentina nudelman@go.fcen.uba.ar
‡Department of Organic Chemistry, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de la Patagonia San Juan Bosco, Comodoro Rivadavia, 9004 Chubut, Argentina riossm@unpata.edu.ar

Abstract—The distribution coefficient of oil residuals between water and the soil under equilibrium conditions is, in the case of Patagonian soils, strongly dependent on the clay contents and humidity of the soil. Other variables such as, the soil salinity and the environmental exposure conditions, also affect the interactions between the phases. The oil residuals are generally accompanied by water spills, that are extracted together with the oil and which, frequently, have high salinity. These salts stay on soils during long times and finally they became part of the soil. The resulting oil aqueous concentrations and the soil-water distribution ratio (Kd) may be strongly influenced by these factors. Based on experimental data of several parameters determined in different regional field samplings, a semi-empiric model was developed that allows prediction of the Kd dependence with the exposure time, the salinity of the equilibrium aqueous concentration and the clay contents of the soil. The Monte Carlo simulation was used in this work. Distribution values of soil conductivity, clays content, and assumed fixed values of the age of the oil spill were used in the model. A set of calculated values of Kd was obtained and the results show a distribution that was probabilistically analyzed. The Kd values increase with increasing age of spill and soil salinity and decrease when the salinity of the initial aqueous concentration is greater than the soil salinity. The determined parameters are useful for modeling of the environmental impact on polluted soils and for the design of remediation techniques.

Keywords—Oil Residuals, Distribution Coefficient, Salinity effect, Semi-empiric Model, Monte Carlo Simulation.

I. INTRODUCTION

The behavior of the compounds in aqueous phase is of critical importance in environmental studies, because solute transport and transformations processes are know to occur predominantly in water (Lane and Loehr, 1992; Manan, 1996). Bioavailability of oil components in contaminated soils is an important regulating factor for biodegradation rates. At lower concentrations, the bioavailability was controlled by desorption/diffusion processes in water (De Jonge et al., 1997).

Sorption to natural solids is an underlying process affecting the transport, degradation, and biological activity of organic compounds in the environment (Pingratello and Baoshan, 1996). The overall sorption capacity is influenced by the nature of the soil organic matter, the mineral composition, the soil moisture content, and the presence of solvent. In dry soils, sorption of nonpolar organics in dry soils is dominated by adsorption onto mineral surfaces, particularly clays (Karimi-Loftfabad et al., 1996; Nudelman et al., 2000).

The simplest and most common method for mathematically expressing the distribution of an organic chemical between soil surfaces and water, is the sorption or distribution coefficient (Kd). Several researchers have found that if Kd is normalized on the basis of the soil’s organic matter or organic carbon content, much of the variation observed among Kd’s over different soils can be eliminated (Dragun, 1998). That there are differences in the sorption of organic compounds on different fractions of organic matter is known (Luthy et al., 1998). Others researchers have found that the extent of adsorption of nonionic organic chemicals onto soil particles surfaces is well-correlated with two empirical measurements of the organic chemical hydrophobicity: the water solubility and the octanol-water partition coefficient (Carmo, 2000; Xia, 2001). These available predictive expressions of Kd do not take into account the “salt” effect, the change of the adsorption coefficient due to a change in the salt content the water. The dependence of adsorption on salt content was approximated with a derivative of the Setschenow equation (Dragun, 1998).

The oil residuals, in exploration and production areas, are generally accompanied by water spill which is extracted together with the oil and, frequently, has similar salinity to sea water. These salts stay on soils during long times and they became part of the soil. Removal of salts from oil and salt contaminated soils before undertaking bioremediation may reduce the time required for bioremediation (Rhykerd, 1995).

The purpose of the present study was to examine the salinity effect on the estimation of the distribution coefficient of oil residuals, due to spills of different ages.