

Some aspects of relationship between ecotoxicological effects of PAHs and their bioavailability in freshly contaminated soils

Volodymyr Snitynsky, Bohdan Krektun

Lviv State Agrarian University, V.Velykoho str, 1, Lviv-Dublany 80381, Ukraine,
(e-mail: lday@mail.lviv.ua)

Abstract

The ecotoxicological effects of bioavailable fractions of phenantrene and pyrene extracted by means of TENAX beads, were described. This makes it possible to use the method in various explorations of ecotoxicological properties of bioavailable concentration of PAHs in soil.

An important role in the realistic estimation of ecological state of soils contaminated with persistent organic pollutants is played not only by quantitative indices of total concentration of pollutant but also by indices reflecting effect of factors, which promote the contaminant accessibility to metabolic processes within the cell of soil organisms. In this respect, the development of the techniques of polycyclic aromatic hydrocarbon (PAH) evaluation of bioavailability is of special interest.

Polycyclic aromatic hydrocarbons belong to a group of organic substances widely spread in the surroundings which possess strictly defined ecotoxicological effects. PAHs in the soil are capable not only of suppressing some chains of metabolic processes in organisms of plants, mezofauna and microbes but also undergo biotransformation being involved in oxidative processes of other metabolic chains of particular species of soil organisms.

PAHs are nonionic organic compounds primarily sorbed by the lipophilic fraction of soil organic matter. The binding inside the organic matrix considerably decreases the transfer of PAHs into aqueous and gaseous phases and thus retards the migration of PAH bioavailable fractions in the soil. Both the solubility of PAHs and the sorption peculiarities of the soil were considered to be the key features determining the bioavailability of PAHs and their ability to migrate in the soil environment. These properties determine the distribution of molecules of the compounds between the soil solution and the particles. These factors to a great extent define the particular part of the total content of pollutants actually affecting the metabolic processes in soil organisms.

Among the methods of PAHs bioavailability estimation in soil, the TENAX- method has proved to be quite efficient. Polyether carbon resin type of TENAX is capable of adsorbing PAHs on their surface as well as within the pores. Solid-phase extraction with TENAX beads is widely employed and described in scientific literature in studying the processes of PAHs biodegradation. In our investigation we managed to prove the efficiency of solid-phase extraction with TENAX beads in evaluating the ecotoxicological effects of these compounds.

Bioavailable fractions of two model PAH compounds (pyrene and phenantrene) were determined in freshly contaminated soil.

Heavy loam ($\%C=3,5$; $pH_{KC}=7,3$) was used in the laboratory study. Soil samples were air-dried and sieved prior to use. Plastic pots were filled with dry soil, soil samples were watered up to 40 % of full water capacity and pre-incubated in darkness at 20^o C. After contamination of soils with pyrene and phenantrene at the level of: 1, 10, 100, 500, 1000 mg/kg, the soil samples were incubated for the next 7 day period.

The bioavailable fraction of PAH compounds was determined using Tenax TA beads as a PAH adsorbent from the aqueous phase according procedure described by Cornelissen. The response of soil microorganisms to PAH contamination was evaluated at the activity level. The potential of nitrification was determined after 2 and 168 hours.

It was observed that the increase of concentration of phenantrene in the freshly contaminated soil causes the augmentation of bioavailable fraction size to 40 % compared to the total concentration of PAHs in the experimental soil. It was shown that the content of the organic carbon in the soil is an important factor affecting the extractability of phenantrene from the contaminated soil. Due to a considerable affinity of the soil organic matter to this type of nonpolar organic substances, the high content of organic carbon can significantly decrease the PAH bioavailability and slow down their circulation in the soil environment between the soil water and the air. Furthermore, a correlation was established between the content of bioavailable fraction of phenantrene and pyrene and nitrification potential of soils.

Our investigation ascertained the efficiency of method of evaluating the ecotoxicological effects of bioavailable fractions of phenantrene and pyrene extracted by means of TENAX beads. It enabled us to use the method in various explorations of ecotoxicological properties of bioavailable concentration of PAHs in soil.

Key words: bioavailability, nitrification potential, phenantrene, polycyclic aromatic hydrocarbons, pyren