ARTICLE IN PRESS

Applied Clay Science xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Applied Clay Science

journal homepage: www.elsevier.com/locate/clay

Research paper

Concentration-dependent and simultaneous sorption and desorption of pyrene and fluorene on major soil minerals in sub-Saharan Africa

Paul N. Diagboya[a,*], Bamidele I. Olu-Owolabi[b], Ezekiel D. Dikio[a], Kayode O. Adebowale[b]

[a] Department of Chemistry, Vaal University of Technology, Vanderbijlpark, South Africa
[b] Department of Chemistry, University of Ibadan, Ibadan, Nigeria

ARTICLE INFO

Keywords:
Polycyclic aromatic hydrocarbons (PAHs)
Competitive sorption
Tropical soils
Soil minerals
Agro-ecological zone
Nigeria

ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) sorption-desorption in soils, as influenced by soils' physicochemical conditions, control the extent of PAHs translocation, persistence and bioavailability. Though mono-PAHs sorption on soils reports abound, co-occurrence of PAHs in the environment is common and affects individual PAHs sorption characteristics competitively or cooperatively. Besides, most reports were not on sub-Saharan soils. Hence, the batch experiments to study simultaneous sorption–desorption of pyrene and fluorene on five soils, with varying minerals contents, from different sub-Saharan agro-ecological zones. Sorption was concentration dependent and increased as concentration. There was higher preference for pyrene, though lower sorption than in mono-PAHs solutions. Irrespective of competition, soil organic matter (≥ 4.5%) caused high pyrene sorption similar to mono-PAHs sorption. At 25 °C, pyrene had lower hysteresis in simultaneous desorption compared to mono-PAHs, while higher hysteresis was observed in fluorene for all soils. Simultaneous sorption was higher at 40 than 25 °C and higher hysteresis exhibited as temperature increased in contrast to desorption at 25 °C. Isotherm model studies showed that simultaneous sorption of both PAHs were on heterogeneous surfaces and are composites of several linear and non-linear isotherms. Ultimately, soil constituents, PAHs concentration, competition for sorption sites, size and structural relationship play vital roles in simultaneous sorption on these soils. Risk of environmental contamination is higher for fluorene than pyrene during co-occurrence and likely so in the warmer and low organic matter soils of northern sub-Sahara.

1. Introduction

Understanding the fate of polycyclic aromatic hydrocarbons (PAHs) in soil is of paramount importance because of soils' roles in global development issues such as food security and global burden of disease. Several PAHs are known to be toxic, some being mutagenic and/or carcinogenic to biota; and thus they have been classified as priority pollutants (ATSDR, 1995; USEPA, 2007; Joseph-Ezra et al., 2014; Javadi et al., 2017). Natural co-occurrence of organic pollutants especially PAHs in the soil environment is ubiquitous but has been enormously supplemented by recent anthropogenic activities resulting in unprecedented soil pollution levels (Lee and Kim, 2002; USEPA, 2007; Pan and Xing, 2010; Olu-Owolabi et al., 2017). In soil, various physical and chemical processes determine the fate of pollutants (Hwang and Cutright, 2002; Teixeira et al., 2011; Diagboya et al., 2015; Mokwenye et al., 2016). Among these processes, sorption is relatively the most studied because data obtained can give valuable information on suitable remediation strategies for the polluted soils (Sparks, 2003; Olu-Owolabi et al., 2015).

Although PAHs are among the most intensively studied pollutants around the world (White and Pignatello, 1999; Zhao et al., 2001; Javier Rivas et al., 2008; Changchaivong and Khaodhiar, 2009; An et al., 2010; Guo et al., 2010; Haftka et al., 2010; Nasser and Mingelgrin, 2012; Biswas et al., 2015; Adesina et al., 2017), there is dearth of information concerning their fate on tropical sub-Saharan soils. This is vital because PAHs fate in soils depends on their interactions with the soil components as well as the prevailing conditions in the soil environment. This implies that PAHs may exhibit different characteristics in different soils formed from different parent materials under different environmental conditions (Hwang and Cutright, 2002; Huang et al., 2003; Olu-Owolabi et al., 2014; Diagboya et al., 2016). Since soils from the various agro-ecological zones (AEZs) of sub-Sahara Africa vary extensively in physical and chemical properties due to different soil forming parent materials and the prevailing environmental conditions (temperature, moisture, and biota), PAHs sorption studies on these soils are worthwhile.

Sorption and desorption of pyrene and fluorene on soils from the various AEZs of sub-Sahara Africa have been reported earlier (Olu-

* Corresponding author.
E-mail address: pauldn2@yahoo.com (P.N. Diagboya).

https://doi.org/10.1016/j.clay.2017.11.037
Received 28 July 2017; Received in revised form 25 November 2017; Accepted 26 November 2017
0169-1317/ © 2017 Elsevier B.V. All rights reserved.

Owolabi et al., 2014, 2015). These studies were carried with mono-PAHs solutions and cannot be used to predict the behaviour of these PAHs when they co-occur as contaminants in soil. Understanding the behaviour of co-occurring PAHs in soil is necessary because PAHs are released into the environment as a mix rather than individual compounds, and the sorption characteristics of the individual PAHs can be modified by the presence of other PAHs (Hwang and Cutright, 2002). Hence, the purpose of this study was to determine the simultaneous sorption characteristics of pyrene and fluorene when both co-occur as contaminants in soils using five soils from different sub-Saharan AEZs. The sorption characteristics were evaluated by determining the effects of PAHs concentration and environmental temperature. The data were analyzed and modeled using various sorption isotherm models as well as compared with sorption characteristics of both PAHs obtained from mono-PAHs sorption experiments.

2. Materials and methods

2.1. Soil sampling, characterization and PAHs solutions preparations

The soil samples used in this study were collected from major sub-Saharan AEZs (Fig. 1a). Five representative surface soils (0–30 cm) samples were obtained from locations relatively free from anthropogenic activities. These were air-dried, crushed gently and sieved through a 230-mesh size sieve and the fine fractions retained for the sorption study. The soils' pH values in milipore ultra-pure water and 1.0 M KCl (ratio 1:1), particle size, organic matter, metals (oxides, exchangeable and trace), and soil mineralogy were determined following the methods earlier described in Olu-Owolabi et al. (2014, 2015, 2016) (Supporting Information, SM 1).

Stock solutions (1000 μg/L each) of pyrene and fluorene were prepared separately in 20% v/v acetonitrile/milipore ultra-pure water and 10% v/v methanol/milipore ultra-pure water, respectively. The working solutions of 100 μg/L each were prepared from the stocks separately in 5% v/v acetonitrile/milipore ultra-pure water and 5% v/v methanol/milipore ultra-pure water, respectively (solubility of both PAHs in water at 25 °C are 135 and 1992 μg/L, respectively). The background electrolyte and biocide used to eliminate microbial degradation for these preparations were 0.005 M $CaCl_2$ and 0.01 M NaN_3, respectively.

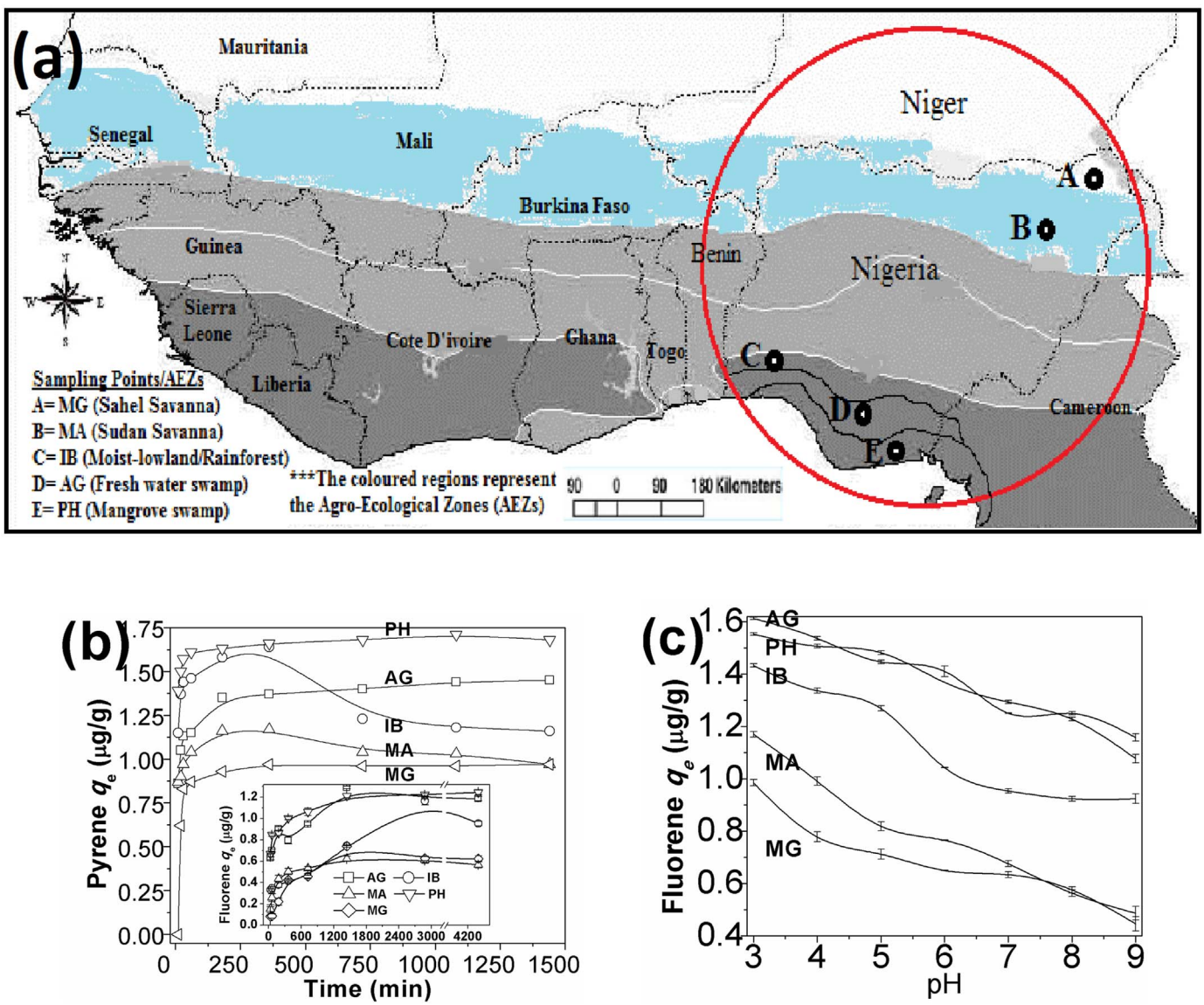

Fig. 1. (a) Sampling locations within the major AEZs (shaded areas) of sub-Saharan West Africa; (b) effect of time on pyrene sorption (Insert: fluorene); (c) effect of pH on fluorene sorption.

Download English Version:

https://daneshyari.com/en/article/8046263

Download Persian Version:

https://daneshyari.com/article/8046263

Daneshyari.com