

Review

Field application of passive sampling techniques for sensing hydrophobic organic contaminants

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ABSTRACT

Progress in the field application of passive sampling techniques for sensing hydrophobic organic contaminants (HOCs) was reviewed. Field applications of *in situ* passive sampling methods can be categorized as (1) measurement of atmospheric and dissolved HOCs; (2) measurement of site-specific phase partition coefficients; (3) bioavailability assessment; and (4) measurement of inter-compartmental flux. Compared to the comprehensive global monitoring of atmospheric HOCs, *in situ* measurements of dissolved HOCs in open water and sediment porewater with passive samplers have remained limited. Polymer-coated fibers with small sampling volumes are preferable for determining site-specific phase partition coefficients, which are important parameters in fugacity-based modeling of the geochemical fate of HOCs. Furthermore, field assessment of bioavailability with *ex situ* or *in situ* passive samplers needs to be further validated, whereas toxicity assessment can be improved with biodegradation or ingestion of particle-bound HOCs by worms taken into account. A passive sampling device was developed and used to obtain the diffusive fluxes of dichlorodiphenyltrichloroethane and its metabolites across the sediment–water interface, but measurements of fluxes of HOCs across the soil–air and air–water interfaces have been far from success.

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1. Introduction

Hydrophobic organic contaminants (HOCs), such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs) and polybrominated diphenyl ethers (PBDEs), in environmental compartments (e.g., air, water

and sediment) have been paid much attention in recent decades. Monitoring of HOCs in air, water and sediment across the globe has provided updates on worldwide occurrence, global geochemical transport and ecological risk of HOCs [1,2]. Conventional sampling methods for sensing HOCs in environmental compartments follow a general protocol of sample collection with active samplers, i.e., a high-volume air sampler, pump and grab sampler, filtration or extraction (Soxhlet and liquid–liquid extraction), and then purification and instrumental analysis [3]. These active sampling methods require power supply which may be difficult to satisfy in

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remote areas. Thus use of conventional active sampling methods to monitor HOCs in the global environment is nearly impossible.

Passive sampling techniques are easy to operate and cost-effective, hence create new opportunities for monitoring HOCs in air, water, soil and sediment throughout the world. For instance, the Global Atmospheric Passive Sampling Network initiated in December 2004 conducted a survey of persistent organic pollutants (POPs) and priority chemicals in air with passive air samplers [4]. Until now, this monitoring program has covered more than 55 sites in urban, rural and remote regions of seven continents [5]. Lohmann and Muir [2] also called for establishing a monitoring network of POPs in global aquatic environment using passive sampling devices, especially with polyethylene (PE) as the sorption phase.

Passive sampling techniques are mainly based on the phase partitioning of target analytes resulting from the chemical potential gradient between the sampler's sorbent phase and sampling matrix [6]. Generally, available passive samplers for HOCs, such as semipermeable member device (SPMD) [7], solid phase microextraction (SPME) fiber [8], polyurethane foam (PUF) disk [1], PE device [9] and polyoxymethylene film (POM) [10], consist of a sorption phase (sorbent) and a protection/support mechanism used to minimize physical/microbial damage and/or facilitate subsequent instrumental analysis. Early applications of passive sampling techniques mainly involved laboratory measurement by passive samplers of dissolved concentrations of HOCs in water or sediment collected

with active sampling methods and transported to the laboratory. However, factors impacting the partitioning processes of dissolved HOCs among the field environmental compartments, such as temperature and salinity, may not be accurately accounted for in laboratory simulation [11]. On the other hand, substantial losses (as much as 50–70%) of PAHs may occur during transport and storage of water samples, even if the samples are stored in dark for only 48 h in glass vials [12]. In addition, particle-bound HOCs can be released during the freezing and thawing processes of solid samples [13]. Therefore, *in situ* passive sampling of HOCs may be an advantageous approach over active sampling in many field applications, and it is worthwhile to comprehend the current state of passive sampling techniques suitable for field applications.

So far, available literature reviews on passive sampling techniques have mostly focused on calibration methods, assembly of passive samplers, and the principles or limitations of limited applications, e.g., biomedical analysis, *in vivo* analysis, and bioavailability measurement [14–18]. Conversely, field applications of passive sampling methods have seldom been reviewed. To fill this knowledge gap, the present review compiles and analyzes available information about the new development of typical passive samplers (Table 1 and Fig. 1) for sensing HOCs in air, water and sediments. The compiled information is synthesized to characterize the field application of passive sampling techniques, such as monitoring data, assessment of bioavailability, determination of site-specific partition coefficients and inter-compartmental flux measurement.

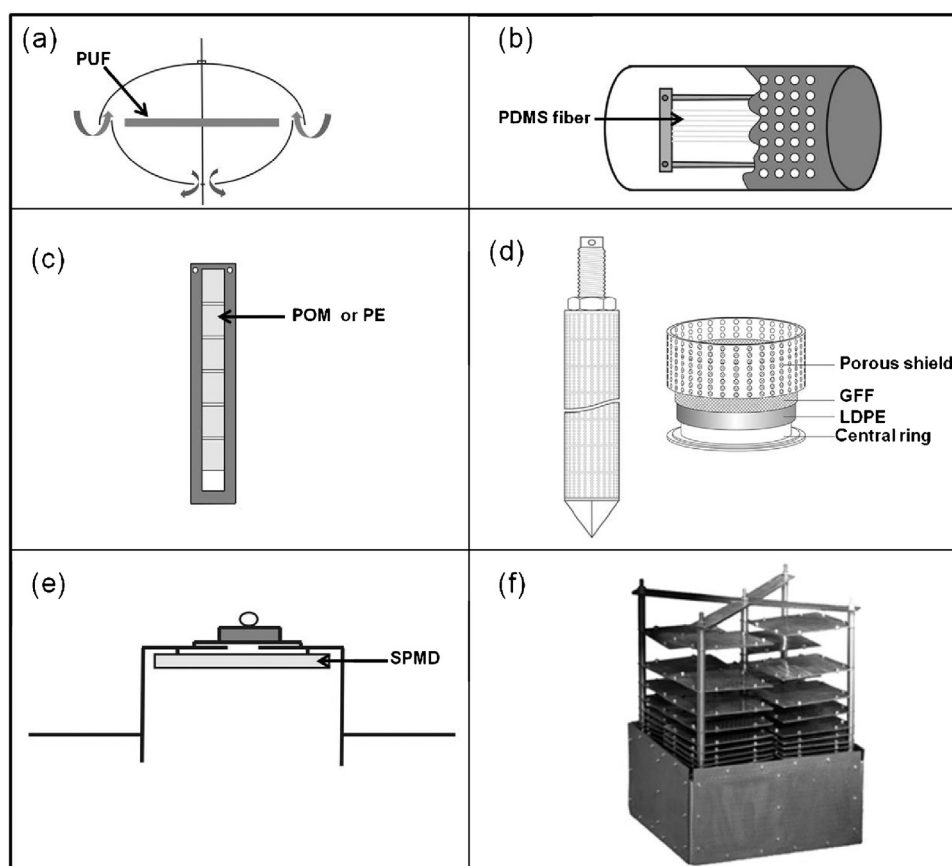


Fig. 1. Typical field passive samplers: (a) polyurethane foam (PUF) disks [1]; (b) polydimethylsiloxane (PDMS) *in situ* sampler [13]; (c) polyethylene (PE) and polyoxymethylene (POM) mounted on a sediment-penetrating rods [32]; (d) multi-section passive sampler [31], LDPE = low density polyethylene, GFF = glass fiber filter; (e) infinite-sink benthic flux chamber [55], SPMD = semipermeable member device; (f) passive sampling device [56].

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