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Construction of the hydrological condition-persistent organic pollutants relationship in the Yangtze River Estuary

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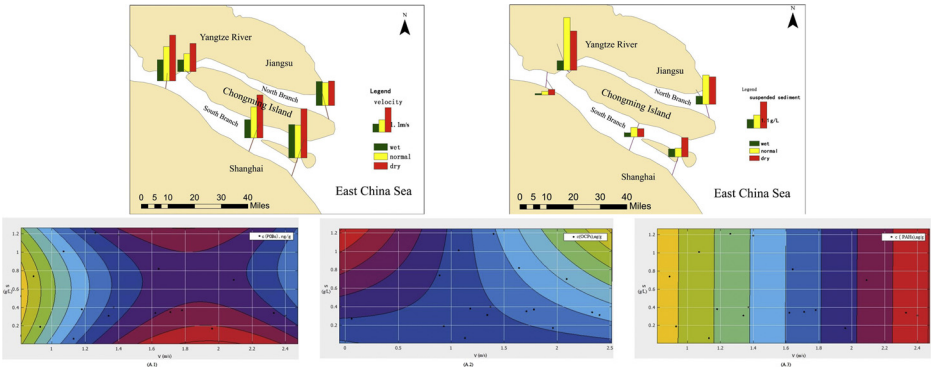
GRAPHICAL ABSTRACT



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ABSTRACT

With anthropogenic activities, the persistent organic pollutants (POPs) accumulated in estuary has been notably concern but the influences of complex hydrodynamic conditions on the fate of POPs in estuary have not fully understood. In this study, the bottom velocity and the concentration of suspended sediment in the Yangtze River Estuary (YRE) were determined using the Acoustic Doppler Current Profiler (ADCP), while the concentration of three typical POPs with distinguishing properties, including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and organichlorine pesticides (OCPs), were determined simultaneously. Then three nonlinear equations were determined for identifying the hotspots of PCBs, OCPs and PAHs in the YRE. The results indicated the goodness-of-fitting of these three equations were satisfactory, indicating the bottom velocity and the suspended sediment level could be used as the reference factor of POPs. For the YRE, the north branch, the upstream of the north branch, and the mouth of the YRE are identified as the hotspots of PCBs, PAHs and OCPs, especially in the normal, flood and dry season, respectively. Simple structure and easy data availability make the results and methods presented in this paper to be easily used as a reference for POPs studies in other regions.

1. Introduction

Persistent organic pollutants (POPs) are synthetic and natural chemicals resulting from burning of organic matter like fossil fuels [1–3]. Typical POPs like polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and organichlorine pesticides (OCPs),

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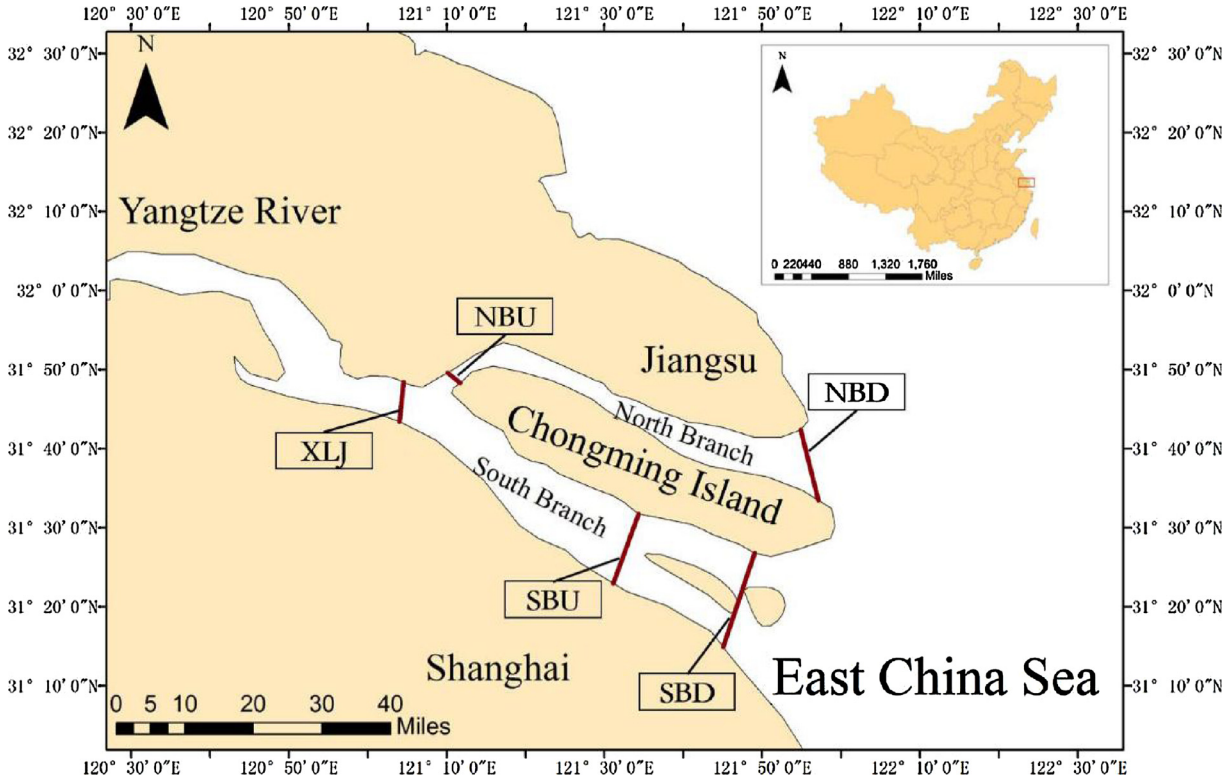

Fig. 1. The Yangtze River estuary, China and the sample sections.

are widely used in pesticides and other chemical productions. However, due to their bioaccumulation, persistence and toxicity characteristics, they have also been listed as prior pollutants by the Stockholm Convention [1,4,5]. To date, rapid development of industrialization and frequent anthropogenic activities have influenced the fate and behavior of POPs [6,7], while hydrophobicity of POPs determines them tend to accumulate in the estuarine sediment as their final sink [4,8].

Many studies have focused on the sources and characteristics of POPs in estuarine sediment because they, acting as the pollutant sources, would impact aquatic life and finally dose harm to human health through food chain [9,10]. For example, transportation and industrial discharge have been identified as the main sources of PCBs in the Scheldt Estuary, Netherland, leading to a relative high concentration of 368 ng PCBs/g dry weight sediments [11]. Besides, Rizzi et al. [12] and Saba et al. [13] have distinguished the types of POPs and their possible sources in Babitonga Bay, Brazil and Newark Bay, USA, respectively. These studies have demonstrated that the spatial-temporal distribution of POPs would be influenced by several physical factors like temperature, pH, salinity and wind [14–16], while adsorption acts as the key process that relate to the fate of POPs in estuarine sediment [17]. A series of laboratory experiments have been conducted by setting large gradient value of factors artificially. However, in the bottom of natural estuarine, most factors were more likely to be vertical-stable rather than horizontal change in a large range [18–20], and hydrodynamic conditions, in terms of the bottom velocity and suspended sediment, play the key role on the fate of POPs in estuarine sediments [21,22]. Compare to other regions, estuary often shows more complex hydrodynamic conditions due to the combined impacts of upstream runoff, intensive tides and longshore currents [23]. However, due to the complexity of field sampling and varying hydrological conditions, the impacts of hydrological conditions on the fate of POPs are mainly conducted in laboratory experiments. Besides, physical-based models, such as the Environmental Fluid Dynamics Code (EFDC), the Fate and Transport Ocean Model (FANTOM) and the Integrated Catchment Contaminants model (INCA), have been used for simulating the hydrological and pollutant processes in estuarine regions [24–27]. However, those models have high requirements on large and comprehensive input data sets, including terrain, land use cover, meteorological and hydrological data, as well as time-consuming computation, which limited them in simulating the accumulation and release of POPs in estuarine sediments under different hydrological conditions. To date, the spatial distribution of typical POPs and their responses to hydrodynamic conditions have not been fully understood, which is important for identifying the possible sinks of POPs in estuarine regions.

The Yangtze River Estuary (YRE) is the estuary of the world's third longest river with frequent land-ocean interactions [28], and the sediments in the YRE have been reported as the final sink for hydrophobic organic pollutants [6]. In our previous study, Gao et al. [29] had analyzed the temporal distribution of PCBs in the YRE by field sampling at 30 locations and found that high values of PCBs always appeared in the flood season. Besides, Chen et al. [30] further modeled the spatial distribution of PCBs using the three-dimensional EFDC and indicated that the temporal variability of PCBs was strongly related to the hydrodynamic conditions in the YRE. However, due to the lack of the detailed hydrodynamic data, the impacts of hydrodynamic conditions on the spatial distribution of PAHs, PCBs and OCPs in the YRE are still limited.

The objective of this study was to propose a simple method for predicting the fate of POPs in the YRE based on key hydrodynamic data that could be easily obtained. In this study, the bottom velocity and the concentration of suspended sediment were monitored by the Acoustic Doppler Current Profiler (ADCP), and the concentration of typical POPs were determined though field sampling. Then three regression equations were constructed by analyzing the correlation between the hydrodynamic conditions and the concentration of PAHs, PCBs and OCPs in estuarine sediments.