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Distribution of priority pollutants in the sediment of Vembanad Estuary, Peninsular India

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ABSTRACT

The existence of Organochlorine pesticides (OCP's) and trace metals in tropical aquatic environments may cause a severe threat on account of their ubiquitous nature and long persistence. Monitoring of such contaminants has assumed immense significance in recent times. The present study assessed the OCP's and trace metal contamination in the surface sediments of the Vembanad wetland system in India. Various pollution indices were calculated to determine the sediment quality of the system and were also compared with uncontaminated sediments. Geo-accumulation index for Mercury varied from moderately to extremely polluted. The mean concentration of pesticide residues and trace metals in the sediments of Vembanad is found to be higher than in other aquatic systems in India. The situation demands further studies which focus on the potential bioaccumulation of OCPs and metals in the benthic food chain, succeeding biota and their impact on human consumption as the system supports a huge population for their livelihood. The Present study provides a baseline information on the spatial distribution of priority pollutants along with ecological risk status of Vembanad estuarine system (VES).

1. Introduction

Priority pollutants are ubiquitously present in tropical aquatic systems due to their widespread application and have received increasing attention as it cause distress to aquatic life. They are the set high priority chemical pollutants defined in the Clean Water Act (USA). Among the priority pollutants organochlorine pesticides and trace metals have been received and retained in the aquatic systems of countries like India where industrial growth is a recent past. In an aquatic sedimentary environment, these pollutants may undergo chemical transformations and can serve as a sink or secondary source of pollutants (Vassilopoulou and Georgakopoulous-Gregoriades., 1993; Mohan et al., 2014). With various biogeochemical changes like turbulences and diagenetic processes, the persistent organic pollutants can remobilize into adjoining water columns and ultimately reach the aquatic organisms. The long-term persistence, bioaccumulation and bio magnification potential of pesticides may pose a severe threat to the entire biosphere (Eulaers et al., 2014; Jahnke et al., 2014; Lee et al., 2015; Niu et al., 2013; Papagiannisa, 2004).The geochemistry of such pollutants in the sedimentary environment may provide information on the health of the system and on the transportation, fate of the contaminants as well.

As reported by various studies, Vembanad Estuarine system (VES) is under immense pressure due to indiscriminate exploitation beyond its supportive capacity (Mohan et al., 2012; 2014; Ramasamy et al., 2017). The pollution of estuaries by priority pollutants is a universal phenomenon, especially in the tropical region. The ecological degradation of this estuary is triggered by urbanisation, tourism, port development and agricultural runoff with a cocktail of organochlorine pesticides and heavy metals. Priority pollutants arising mainly from industrial, agricultural and municipal discharge deteriorate the quality of surrounding Kuttanad Agricultural wetland system (Sruthi et al., 2017). There are many industries situated along the bank of the estuary which manufacture DDT, Monocrotophos, Malathion, Butachlor- like chemicals and a few metallurgical industries discharge their effluents directly into VES after minimal treatment. Various studies report the pollution status of VES by means of metals, acid volatile sulfide (Shyleshchandran et al., 2017), polycyclic aromatic hydrocarbons (PAHs) and pesticides (Akhil and Sujatha, 2014; Ramzi et al., 2016).

Being a Ramsar site, estuarine sediment quality of VES deserves much scientific attention. Hence, in this study trace metals and organochlorine pesticides were quantified from the surface sediments and the environmental threat posed by these chemical mixtures was evaluated using sediment quality indices and health risk assessment.

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Specifically, the objective of the present study is, a) to quantify the spatial distribution of organochlorine pesticides and trace metals b) to assess the environmental, ecological and health risk posed by the priority pollutants.

2. Materials and methods

2.1. Study area

Vembanad Estuarine System (VES), situated on the coast of Kerala is a tropical estuarine system which extends from 9° 30′ N–10° 10′ N and 76° 10′ E–76° 25′ E, one of the Ramsar sites (No. 1214) having an international importance (Menon et al., 2000). It is the most extensive wetland system in the country, it also serves as a large number of people living around VES. The study was done on the northern portion of the estuary.

2.2. Sample collection

Forty-eight surface sediment samples were collected from 12 locations (four samples from each site) during three seasons of a year from northern limb of Vembanad using a Van Veen grab sampler having two-kilogram capacity (Fig. 1). Top 25 cm of the surface sediments were collected and each sediment sample is a combination of three to four subsamples, collected from the same location, pooled and homogenized, and a single sample was drawn from this pool for further analysis. The sampling locations covers Elloor industrial belt, Varapuzha, Willington Island area and Cochin City. The sediment samples were placed into pre-cleaned self-sealed polythene cover and stored in an icebox. Prior to analysis, all the samples were divided into three subsamples. One sub-sample was used for the texture analysis, pH and conductivity (sieved through < 2 mm sieve). The second portion of the sieved (< 63 mm) sample was used for the trace metal analysis. Remaining portion of the sample was ground, sieved (< 0.2 mm sieve) and used for the analysis of pesticides residue and organic carbon. Sample preparation and extraction processes were done in Class 100 clean hood facility to reduce contamination.

2.3. Extraction method

The extraction method adopted for the pesticides residue and trace metal analysis are as follows.

2.3.1. Extraction for pesticides residue

Pesticides residue extraction from sediment samples were done by the modified shake-flask method (Sruthi et al., 2017). Twenty gram of sediment samples (< 2 mm size) were taken in screw-capped conical flasks along with 30 ml of HPLC-grade acetone and undergone continuous shaking for 90 min at 300 rpm. The resulting mixtures were centrifuged for 15 min at 3000 rpm, and supernatant solutions were collected as extracts. Each extract was filtered (Whatman no. 41 filter paper), and the filtrate was passed through a chromatographic column (sintered) packed from top to bottom with high-purity anhydrous sodium sulphate, silica gel and activated alumina respectively for cleanup (US Environmental Protection Agency Method 3630C). The resultant extracts were concentrated to 1 ml with a rotary vacuum evaporator at 50 °C with 500 psi. After concentrating, the extracts were transferred to pre-cleaned glass vials and sealed using parafilm to avoid further contact with air. These vials were kept under refrigeration until the analysis. These extracts were again filtered using 0.22 μm syringe filter (to ensure the purity) before the analysis.

2.3.2. Extraction for trace metals

Sediment samples (0.2–0.25 g) were taken in the digestion tube

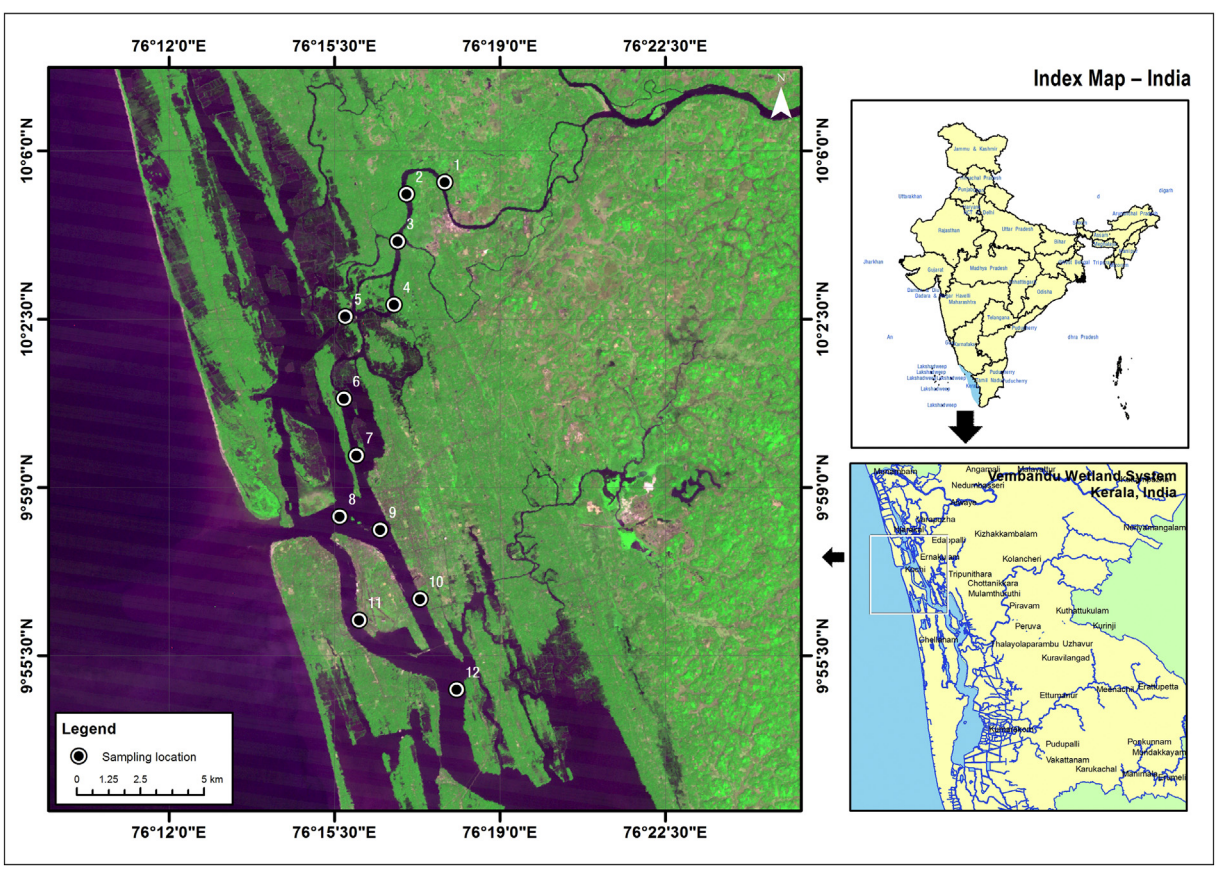

Fig. 1. Study area and sampling sites of Vembanad Estuarine system, India.

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