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Monitoring of linear alkyl benzenes (LABs) in riverine and estuarine sediments in Malaysia

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Abstract The aim of this a pioneering research is to investigate linear alkylbenzenes (LABs) as biomarkers of sewage pollution in sediments collected from four rivers and estuaries in the south and east of Peninsular Malaysia. The sediment samples went through Soxhlet extraction, two-step column chromatography purification, fractionation and gas chromatography–mass spectrometry (GC–MS) analysis. Principal component analysis (PCA) with multivariate linear regression (MLR) was used as well for source apportionment of LABs. The results of this study showed that total LAB concentration was

36–1196 ng g⁻¹dw. The internal to external isomer ratios (*I/E* ratio) of LABs were from 0.56 to 3.12 indicated release of raw sewage and primary and secondary effluents into the environment of south and east of Peninsular Malaysia. Our research supported that continuous monitoring of sewage pollution to limit the environmental pollution in riverine and estuarine ecosystem.

Keywords Detergent · Internal over external isomers ratio · Linear alkylbenzenes · Pollution · Sewage

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Introduction

Despite increasing urbanization and industrialization in Peninsular Malaysia, sanitary sewer systems are existing in poor quality (Alkhadher et al., 2020b; Magam et al., 2015) including those in populous and developed areas such as south of Peninsular Malaysia. Land-based pollutants including industrial and municipal sewage are washed into several the rivers and estuary areas. As a result, rivers in this region are potentially influenced by different anthropogenic discharges (Keshavarzifard et al., 2016a, 2016b; Shahbazi et al., 2010). Monitoring of the sewage pollution is of high priority in tropical countries such as Malaysia since river water is used for drinking purposes and recreational activities by the tourists and the local community inhabiting along these rivers and estuaries. Furthermore, the aquatic environment of tropical regions with high biodiversity is more sensitive to pollutants caused by different anthropogenic activities (Masood et al., 2016; Wei et al., 2014).

Molecular markers are suitable tools widely used to trace sources of anthropogenic inputs in the environment. One of these molecular markers is linear alkylbenzenenes (LABs) which are used to trace the release of industrial and municipal waste (Thomes et al., 2019). LABs come from incomplete sulfonation of LABs during the production process of linear alkyl benzene sulfonate (LAS)-type detergents, one of the most common anionic surfactant groups used in the synthetic detergents industry since the 1960s. LABs are more persistent than LASs in the aquatic environment (Eganhouse et al., 1988), and although LAS-type detergents contain low amounts of LABs, widespread consumption of detergents results in a severe release of LABs through municipal and industrial wastewaters

into the aquatic environments (Takada & Ishiwatari, 1987).

LABs are hydrophobic compounds having octanol–water partition coefficient (K_{OW}) of ~ 7 –10; therefore, they usually sorb to sewage which is rich in organic matter (Murray et al., 1987; Sherblom et al., 1992; Takada et al., 1994). LAB structure is comprised of normal alkyl C_{10} – C_{14} chains having phenyl substitution in various positions making different LAB isomers. The external isomers of LABs are readily biodegraded due to the position of phenyl substitution at or near the alkyl chain end, whereas the degradation of the internal isomers of LABs is less probable due to the inner position of phenyl substitution. As a result, the abundance of different LAB isomers can be a sign of the degree of degradation (Takada & Ishiwatari, 1990). Moreover, the difference in the occurrence of LAB isomers is a reflection of the types of sewage discharge ranging from raw sewage to secondary effluents and severity of these discharges (Cabral & Martine, 2018; Masood et al., 2018; Tsutsumi et al., 2002). Takada et al. 1990 developed a ratio on the basis of the proportion of the internal versus external isomers of LABs in the marine environment, which is known as *I/E* ratio, which is used a tool to show the degradation of LABs. LABs have been applied as molecular markers of sewage contamination in various locations and different environmental matrices across the globe (Medeiros & Bicego, 2004; Magam et al., 2015; Martins et al., 2008, 2014; Ni et al., 2009; Venkatesan et al., 2010). For instances, they investigated in sediments (Ishiwatari et al., 1983; Wang et al., 2012), riverine suspended particles (Ni et al., 2008), biota (Phillips et al., 2001; Tsutsumi et al., 2002), industrial wastes (Zhang et al., 2012) and municipal wastes (e.g. Oller et al., 2011).

LABs are extremely related to anthropogenic activities. Therefore, they can indicate the significance of anthropogenic impacts on the aquatic environment of Malaysia. While previous studies investigated the composition of LABs in the Penang Estuary, Port Klang, Negeri Sembilan, Malacca, Johor Bahru and Sarawak Rivers (Alkhadher et al., 2016; Isobe et al., 2004; Magam et al., 2012), no data are available on LABs in the southern and eastern part of Peninsular Malaysia. This research was carried out to fill this data gap and sediments from Segget, Kuantan, Terngganu and Kelantan Rivers in south and east of Peninsular Malaysia were studied for LAB occurrence and

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