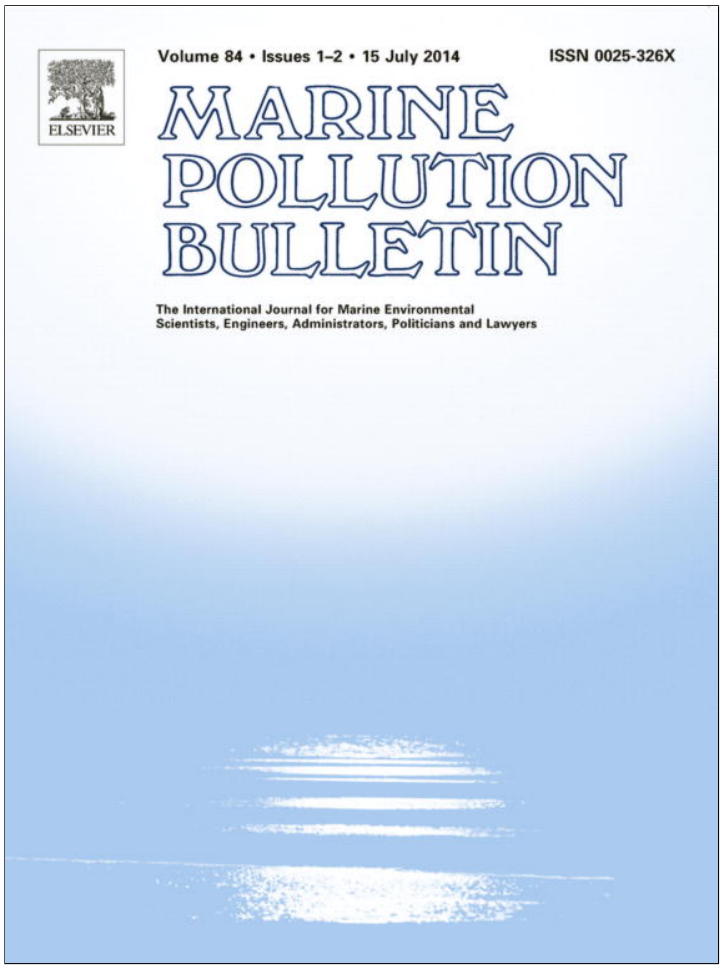

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Surfactants in the sea-surface microlayer and atmospheric aerosol around the southern region of Peninsular Malaysia

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ABSTRACT

This study was conducted to determine the composition of surfactants in the sea-surface microlayer (SML) and atmospheric aerosol around the southern region of the Peninsular Malaysia. Surfactants in samples taken from the SML and atmospheric aerosol were determined using a colorimetric method, as either methylene blue active substances (MBAS) or disulphine blue active substances (DBAS). Principal component analysis with multiple linear regressions (PCA–MLR), using the anion and major element composition of the aerosol samples, was used to determine possible sources of surfactants in atmospheric aerosol. The results showed that the concentrations of surfactants in the SML and atmospheric aerosol were dominated by anionic surfactants and that surfactants in aerosol were not directly correlated ($p > 0.05$) with surfactants in the SML. Further PCA–MLR from anion and major element concentrations showed that combustion of fossil fuel and sea spray were the major contributors to surfactants in aerosol in the study area.

1. Introduction

The sea-surface microlayer (SML) is defined as a layer of the ocean's surface, tens to hundreds of μm deep, which is in direct contact with the atmosphere and where the transfer of chemical compounds is controlled by complex physicochemical processes (Liss and Duce, 2005; Guitart et al., 2007; Cunliffe et al., 2013). According to García-Flor et al. (2005), the SML is enriched by the accumulation of organic compounds such as proteins, carbohydrates, surfactants, lipids, pollutants and other organic residues. These organic compounds have the potential to change the surface properties of the ocean, for example the hydrophobicity (Olkowska et al., 2013). The SML also plays an important role in coastal and eutrophic oceanic regions due to the increased concentration of organic materials with surfactant properties in these areas. These materials have been shown to originate from both anthropogenic and natural sources (Frew et al., 1990; Brinis et al., 2004). A study by Wurl and Obbard (2004) has shown that the amount of dissolved organic matter (DOM) in the SML that has surface-active substances (i.e. surfactants) will influence the energy and mass exchange processes between sea and atmosphere, which may in turn lead to climatic changes (Sukhapan and Brimblecombe, 2002; Mazurek et al., 2008; Schwier, 2012). One proposed mechanism for climatic change is if aerosol particles gain a coating of surfactants, the particles are more likely to initiate cloud droplet formation (Sareen et al., 2012), therefore increasing cloud cover. Increased cloud cover has been shown to result in global temperature changes (Gorbunov et al., 1998; McNeill et al., 2014).

Surfactants in the SML will affect the solubility of compounds in the ocean by altering the surface tension of water (Andrews and Larson, 1993; Frew et al., 2004; Laha et al., 2009). As a consequence, the presence of surfactants will influence the distribution of pollutants dissolved in the SML. Organic pollutants, such as polycyclic aromatic hydrocarbons (PAHs), will have elevated solubility in the presence of surfactants, leading to increased concentrations in seawater and negatively affecting water quality (Cincinelli et al., 2001). Studies have shown that the accumulation of surfactants in the SML has a negative effect on aquatic species in both marine and freshwater ecosystems (Olkowska et al., 2014). As shown by previous studies, surfactants are toxic to marine and freshwater species and induce oestrogenic responses in fish

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