Marine Pollution Bulletin 156 (2020) 111269

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Input of organic matter in Brunei Bay, East Malaysia, as indicated by sedimentary steroids and multivariate statistics

Swee Yun Pang[a,*], Joo Hui Tay[b], Suhaimi Suratman[a], Bernd R.T. Simoneit[c], Norhayati Mohd Tahir[a,d,**]

[a] Institute of Oceanography and Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia
[b] Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Malaysia
[c] Department of Chemistry, College of Science, Oregon State University, Corvallis, OR 97331, USA
[d] Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

ARTICLE INFO

Keywords:
Allochthonous input
Brunei Bay
Coprostanol
PCA
Sterols

ABSTRACT

Brunei Bay is one of the most important marine environments of East Malaysia (South China Sea), covering many productive ecosystems with activities including fisheries, tourism, and main shipping lanes for petroleum transfers. Evaluation of the sources and distributions of steroids in the surface sedimentary organic matter was carried out by gas chromatography–mass spectrometry (GC–MS). The concentrations of the total identified sterols (TIS) ranged between 0.81 and 12.69 μg g^{-1} dry weight, and the total sterones were between 0.11 and 5.66 μg g^{-1} dry weight. The coprostanol level was comparatively low (< 0.10 μg g^{-1}), and the multi-biomarker proxies indicated that the region did not exhibit significant contamination from sewage effluents. Principal component analysis (PCA) revealed the coastal environment of the study area was dominated by allochthonous (mainly terrestrial) organic matter input.

Brunei Bay is located between the East Malaysian territories of Sabah, Sarawak, the Federal Territory of Labuan in Malaysia and the neighbouring country Brunei Darussalam, at coordinates 4°45′–5°02′N and 114°58′–115°10′E. Brunei Bay covers many ecosystems, including estuaries, mangrove swamps, wetlands and mudflats, which offer a vast array of biological diversity and productive ecosystems (Ali and Mohd Ariff, 2007; Abdullah et al., 2017; Satyanarayana et al., 2018). The prolific reproductive capacity of the nearby mangrove forests and peat swamps are of greatest ecological importance in the area. The bay forms an important part of the regional hydrological systems, water resources, and carbon storage. It also has several other functions such as a medium for transportation, recreation, breeding ground and habitat for many marine organisms, plants and marine mammals (Ali and Mohd Ariff, 2007; Satyanarayana et al., 2018). Most importantly, the area has been identified as a potential reservoir for gas and oil in the Sabah Basin and Baram Delta Province off Brunei and Sarawak (Abdullah et al., 2017).

Specific organic molecular markers or biomarkers have been used as a tool to understand environmental processes and interactions. Steroids are persistent in the environment and consequently have a long geological record (Volkman, 1986), making them useful as biomarkers. Steroids are a group of biolipids that can be used to distinguish allochthonous and/or autochthonous derived organic matter (OM) in environments (Volkman, 1986; Mudge and Norris, 1997). Terrestrial plants have been shown to contain high amounts of C_{29} sterols (stigmasterol and sitosterol) (Volkman, 1986; Jaffé and Hausmann, 1995; Wisnieski et al., 2014), which are used as biomarkers for vascular plants. However, some seagrasses, cyanobacteria, and phytoplanktonic species also contain considerable amounts of C_{29} sterols (Nishimura and Koyama, 1977; Volkman, 1986; Jaffé and Hausmann, 1995; Volkman et al., 1999). Brassicasterol (C_{28}) on the other hand occurs at low concentrations in higher plants, but is predominant in OM derived from phytoplankton species, cyanobacteria, green algae, bivalves, molluscs, and diatoms such as haptophytes and cryptophytes (Volkman, 1986; Bayona et al., 1989; Laureillard and Saliot, 1993; Volkman et al., 1999). C_{30} sterols, such as dinosterol and 24-methylenecholesterol, can be used to distinguish input of OM from diatoms and dinoflagellates (Volkman, 1986; Volkman et al., 1993, 2008). Cholesterol (C_{27}) is commonly present in marine sediments and occurs in a wide range of marine organisms such as algae, zoo- and phytoplankton and marine mammals (Volkman, 1986, 2005). Steroids can also be used to distinguish between wastewater and biogenic OM. For example, the ratio of coprostanol to *epi*-coprostanol (cop/e-cop) has been used to differentiate

* Corresponding author.
** Correspondence to: N. Mohd Tahir, Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.
E-mail addresses: p.sweeyun@gmail.com (S.Y. Pang), hayati@umt.edu.my (N. Mohd Tahir).

https://doi.org/10.1016/j.marpolbul.2020.111269
Received 21 October 2019; Received in revised form 1 May 2020; Accepted 11 May 2020
Available online 16 May 2020
0025-326X/