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Bacteriohopanepolyols in tropical soils and sediments from the Congo River catchment area



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ABSTRACT

The Congo River basin drains the second largest area of tropical rainforest in the world, including a large proportion of pristine wetlands. We present the bacteriohopanepolyol (BHP) inventory of a suite of tropical soils and, from comparison with published data, propose some initial ideas on BHP distribution controls. Strong taxonomic controls on BHP production are evident in wetland sediments. Dominant within the suite were 35-aminobacteriohopane-31,32,33,34-tetrol (aminotetrol) and 35-aminobacteriohopane-30,31,32,33,34-pentol (aminopentol), indicating aerobic methanotrophy. A narrow range and low mean relative abundance of 30-(5'-adenosyl)hopane (adenosylhopane) and related compounds, collectively termed “soil marker” BHPs, were observed in Congo soils (mean 17%, range 7.9–36% of total BHPs, $n = 22$) compared with literature data from temperate surface soils and Arctic surface soils (mean 36%, range 0–66% of total BHPs, $n = 28$) suggesting a greater rate of conversion of these BHP precursors to other structures.

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1. Introduction

Bacteriohopanepolyols (BHPs) are highly functionalised pentacyclic triterpenoids produced by many aerobic bacteria, as well as a number of obligate and facultative anaerobic bacteria (e.g. Rohmer et al., 1984; Sinnighe Damsté et al., 2004; Talbot et al., 2008; Eickhoff et al., 2013). Only bacteria containing the gene encoding for squalene hopane cyclase (*sqhC*; Ochs et al., 1992) are able to biosynthesise hopanoids. Biosynthesis of BHPs is believed to be limited to < 10% of all bacterial species in most communities (Pearson et al., 2007). The initial step in BHP synthesis is the cyclisation of squalene (controlled via the *sqhC* gene), with the addition of the hopanoid side chain (via the *hpnH* gene), leading to the production of 30-(5'-adenosyl)hopane (adenosylhopane; **1a**; Fig. 1; Bradley et al., 2010). It is believed that all hopanoid producing bacteria synthesise adenosylhopane as a BHP precursor; however, few hopanoid producers have been observed accumulating

adenosylhopane and only one species has been found to contain the related compound, adenosylhopane type 2 (**1c**) (e.g. Talbot et al., 2007 and references therein; van Winden et al., 2012a). All species in which adenosylhopane has been identified were also found to contain a range of other BHPs, including bacteriohopane-32,33,34,35-tetrol (BHT), 35-aminobacteriohopane-32,33,34-triol (aminotriol) or both (Talbot et al., 2007, 2008; van Winden et al., 2012b). These and other BHPs are formed following cleavage of the adenine moiety (Bradley et al., 2010; Liu et al., 2014), but it is unknown why accumulation of adenosylhopane occurs only in terrestrial systems (soils in particular) and not in marine sediments. This suggests that the function of adenosylhopane is not restricted to that of a biosynthetic precursor, or it would likely accumulate in all settings.

While many BHPs have multiple bacterial sources, for example BHT (**1b**; Fig. 1; e.g. Talbot et al., 2008 and references therein), some have only a few sources and can be linked to specific biogeochemical processes. Adenosylhopane (**1a**) and related compounds, including C-2 methylated homologues (**2a**, **1c**, **2c**, **1d** and **2d**), have been suggested to be biomarkers for soil organic carbon (OC)

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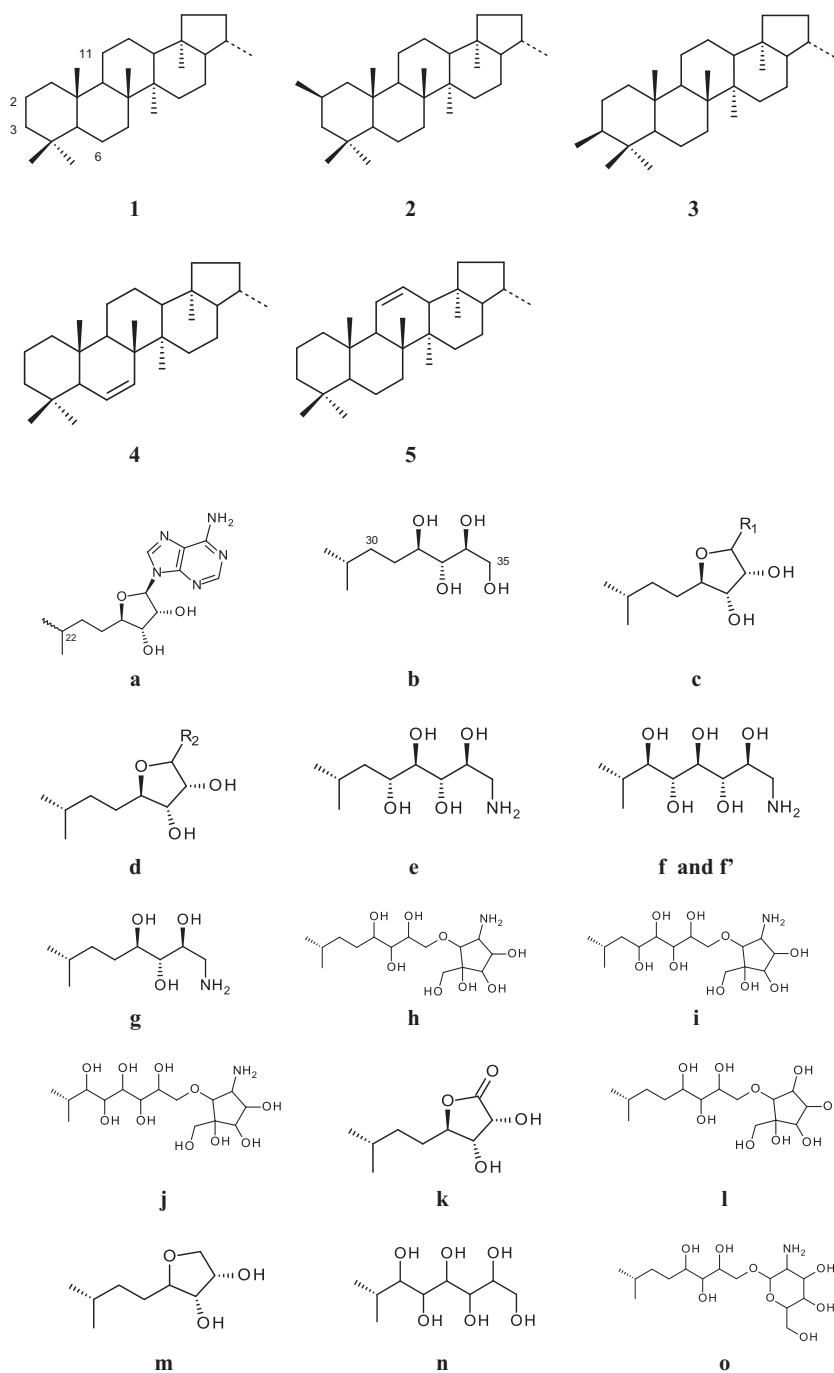


Fig. 1. Structures of BHPs in Congo samples.

transport (Cooke et al., 2008b, 2009; Zhu et al., 2011; Doğrul Selver et al., 2012, 2015). Another group of diagnostic markers comprises those produced by aerobic methane oxidising bacteria (methanotrophs), including 35-aminobacteriohopane-31,32,33,34-tetrol (aminotetrol; **1e**); 35-aminobacteriohopane-30,31,32,33,34-pentol (aminopentol; **1f**), unsaturated aminopentol (**4/5f**) and aminopentol isomer (**1f'**; e.g. Talbot and Farrimond, 2007; Zhu et al., 2010; van Winden et al., 2012b; Berndmeyer et al., 2013; Talbot et al., 2014).

BHP signatures in the geological record are thought to reflect changes in microbial communities at the time of deposition, with multiple factors controlling their distribution. For example, Wagner et al. (2014) suggest aminopentol in sediments dating back 30 Ka from the Amazon fan, is derived from the Amazon

catchment, with fluctuation in concentration reflecting persistent export of biomarkers from wetlands followed by reworking of sediments within the marine environment. An investigation of suspended particulate matter (SPM) along a tropical river-ocean water column transect also suggested that terrigenous organic matter (OM) exported to marine sediments could provide a significant contribution to the marine sedimentary hopanoid inventory (Sáenz et al., 2011). Therefore, in coastal marine environments, well constrained modern terrestrial BHP end members are required to facilitate reliable interpretation of sedimentary BHP profiles.

Studies of soil BHP distributions have focussed mainly on Northern Hemisphere sites (Cooke et al., 2008a; Xu et al., 2009; Cooke, 2010; Rethemeyer et al., 2010; Kim et al., 2011) and found

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