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First evidence of prehistoric humans-induced fire in India: clues from macro-charcoal, biomarkers distribution and compound-specific stable isotopes

Deepak Kumar Jha, Rahul Samrat, and Prasanta Sanyal
Department of Earth Sciences, Indian Institute of Science Education and Research Kolkata, Nadia, India
(deepak.geo@outlook.com)

Fire disturbance appears to be one of the vital processes in shaping vegetation composition and landscape dynamics of an area. It is an essential driver of ecosystem structure, in close association with environmental conditions. Environmental factors, as well as human, can equally induce the fire at the stand. Untying the natural vs. anthropogenic factors is important to comprehend the paleoclimatic conditions at a regional and global scale. Therefore, identifying the fire events from chronologically well-constrained archaeological sites would provide an ideal opportunity to decode its cause and impact on the terrestrial environment. Hence, the present study is conducted on the fluvial cliff sections, which preserved the tools and artefacts from Lower Paleolithic (~100 ka) to Neolithic (~3 ka) phases in the Belan valley, north-central India.

In this study, paleosols samples (n=49) were collected from six sedimentary sections of archaeological sites. Paleosols were analysed for *n*-alkane distribution pattern, *n*-alkane ratio (C_{16}/C_{29} and C_{16}/C_{31}), $\delta D_{n\text{-alkane}}$ values, $\delta^{13}C_{n\text{-alkane}}$ values and macro-charcoal (CHAR) to reconstruct the vegetation, climate and fire events. The n-alkane (C_{15} to C_{35}) distribution signature, average chain length ($ACL_{15\text{-}33}$) and carbon preference index ($CPI_{25\text{-}33}$) values are used to distinguish the aquatic vs. terrestrial contribution in the organic matter (OM). The higher $CPI_{25\text{-}33}$ and $ACL_{15\text{-}33}$ values suggest terrestrial plants derived OM dominance in the paleosols. Four samples with lower $CPI_{25\text{-}33}$ (~1.0) and $ACL_{15\text{-}33}$ (~23.0) suggests higher degradation of OM. Moreover, the lower $CPI_{25\text{-}33}$ samples also showed a dominance of short-chain even-numbered alkanes (maximum at C_{16} or C_{18}). A similar observation in short-chain *n*-alkanes was reported from the archaeological site with known fire events (Eckmeier and Wiesenberg, 2009). Also, the CHAR analyses (n=40) suggests that the degraded paleosols (lower CPI and ACL) have suffered thermal alteration. The CHAR and *n*-alkane ratio suggest paleofire events in the Belan valley during i) ~100 to 95 ka, ii) ~60 to 55 ka, iii) ~42 to 37 ka, iv) ~26 to 20 ka and v) ~8 to 3 ka. $\delta D_{n\text{-alkane}}$ values suggested lower rainfall conditions during Large Glacial Maximum (LGM; ~25 to 18 ka). The intensification in rainfall observed during i) ~100 to 75 ka and iii) ~18 to 3 ka, which also corresponds to some fire events. The $\delta^{13}C_{n\text{-alkane}}$ values suggest the dominance of grassland during LGM, which was favourable for wildfires. Further, the fire event during ~26 to 20 ka identified at Main Belan temporarily overlays with Mahagara and Koldihwa site. The lack of any significant signature of thermal degradation of paleosols (supported by *n*-alkanes) in Koldihwa and Mahagara suggests the extra-local nature of

the fire. The higher rainfall is an unfavourable condition for natural wildfires. Further, the fire disturbance increases in the early-Holocene, which overlaps with the timing of high rainfall condition and agricultural activity in the Belan valley. Therefore, this study postulates that the prehistoric humans-induced fire from ~60 ka onwards.

Eckmeier, E. and Wiesenberg, G.L., 2009. Short-chain *n*-alkanes (C16–20) in ancient soil are useful molecular markers for prehistoric biomass burning. Journal of Archaeological Science, 36(7), 1590-1596.