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学 位 論 文 審 査 の 要 旨

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学 位 論 文 題 名

Hydroxy fatty acids as fingerprint biomarkers for the atmospheric transport of soil microorganisms and terrestrial higher plant metabolites

（土壌微生物と陸上高等植物代謝物質の大気輸送バイオマーカーとしてのヒドロキシ脂肪酸）

Lipid biomarkers have long been employed as a powerful tool to assess the relative significance of soil microorganisms, epicuticular plant waxes and also, to some extent, for characterizing microbial communities in different environmental archives. Among the various lipid class compounds, hydroxy fatty acids (FAs) are one such proxy due to their ubiquitous occurrence as an essential membrane component of soil microorganisms and higher plant waxes. In particular, the positional β-isomers of hydroxy FAs having carbon chain length from C_{10} to C_{18} are specific to endotoxin/lipopolysaccharides (LPS) of Gram-negative bacteria (GNB). The long-term exposure to airborne endotoxin can cause severe allergies and infections in human beings. Apart from β-, other positional isomers of hydroxy FAs such as α- and ω-short-chain homologues have the potential to be used as tracers of soil microorganisms. However, they are also abundant in microalgae, cyanobacteria, sea grasses, and plant waxes. Moreover, these hydroxy FAs can also act as intermediate products of photochemical as well as microbial oxidation of long-chain monocarboxylic acids to dicarboxylic acids.

Hydroxy FAs from soil microbes and plants can be emitted into the atmosphere due to the wind abrasion during dust events and soil-dust re-suspension during biomass burning (forest fires/agricultural burning). Once in the atmosphere, these hydroxy FAs can be transported to distant places and, thus, can have severe impacts on climate, human health and downwind ecosystems. The major objectives of my thesis are to better understand the source regions, atmospheric transport and deposition of soil- and plant-associated bacteria, and also, higher plant metabolites in the East Asian outflow (Asian dust) to the North Pacific. To accomplish these targets, hydroxy FAs were measured in different atmospheric samples including aerosol (urban, coastal, marine), snow (fresh and snow pit) and rainwater samples collected from the East Asian outflow.

Results obtained from my thesis contribute to fill-up the gap between the sources of hydroxy FAs and their deposition into fresh water and marine sediments. A clear seasonal trend in the atmospheric abundances of hydroxy FAs over marine (Jeju and Chichijima) islands is noteworthy with spring/winter maxima and summer/autumn minima. Furthermore, these seasonal cycles are consistent with the prevailing meteorology. Air mass back-trajectories and other soil microbial tracers (such as trehalose) indicate the influence of Asian dust outbreaks originating from Mongolian and Gobi Deserts and also from China loess plateau during winter and spring. To examine the influence of open biomass burning on soil microbes, hydroxy FAs have also been measured in wheat residue combustion derived aerosols over Mt. Tai, North East China. These analyses have revealed significant emissions of β-hydroxy FAs (tracers of GNB) and endotoxin in high biomass burning events. It has been also found that these hydroxy FAs can be removed from the atmosphere efficiently by snow and rain as compared to aerosols.

The overall results obtained through my study clearly document the long-range atmospheric transport of hydroxy FAs, which are tracers of soil microbes (bacteria, fungi, protozoa) and higher plant waxes, from the Asian continent to the North Pacific. The Asian dust outbreaks in spring can lead to increase in atmospheric abundances of hydroxy FAs and, thereby, resulting in the occurrence of health impacts in downwind regions due to the exposure to these airborne particles. This chemical marker based approach (culture independent technique) is a suitable tool for the rapid and comparative analysis of bacterial dry mass and their endotoxin in the various environmental samples, which excludes the need of biological recovery and microbial cultivation.

In addition to the excellent academic knowledge in the research, her academic records throughout the Ph. D course are excellent. Based on these evidences, the committee reached to a conclusion that Tyagi Poonam deserves to become a Doctor of Environmental Science.