Geophysical Research Abstracts,
Vol. 11, EGU2009-6076, 2009
EGU General Assembly 2009

Saccharide Composition in Fine and Coarse Particulate Matter and Soils in Central Arizona and Use of Saccharides as Molecular Markers for Source Apportionment

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The desert southwestern United States routinely exceeds health-based standards for coarse particulate matter [1]. PM10 concentrations are high in both urban and rural areas and are believed to originate from fugitive dust emissions from agricultural fields and roads and soil erosion from the surrounding desert locations. Soil together with its associated biota contains a complex mixture of biogenic detritus, including plant detritus, airborne microbes comprised of bacteria, viruses, spores of lichens and fungi, small algae, and protozoan cysts [4][5], which can mostly become airborne when winds are strong enough and soil dry enough to be re-entrained into the atmosphere [3]. Other potential sources to PM10 may include primary biological aerosol particles (PBAPs), given a multitude of flower, grass, and fungal species that thrive in the Sonoran desert and actively release pollens and spores throughout the year [2]. However, because soil and fugitive dust is also believed to contain a large number of these biological particles and is considered as a secondary host of PBAPs [3] [4], the role and contribution of PBAPs as a direct ambient PM source in the desert southwest have not been clearly stated or investigated.

In an effort to identify and assess the relative contribution of these and other major PM sources in the southwestern US region, and particularly to assess the contribution from soil and fugitive dust, a series of ambient PM samples and soil samples were collected in Higley, AZ, USA, a suburb of the Phoenix metropolitan area which has seen rapid urban sprawl onto agricultural lands. Because of their suggested ability to track biologically important organic materials from natural environment [4][6][7][8][9][10], saccharides were chosen as the key compounds to trace the release of soil dusts into the atmosphere, and to elucidate other major sources that contribute to the PM levels in this location in the arid southwestern US. To this end, saccharide compounds were analyzed in size segregated soil and ambient PM samples at Higley; intra- and inter- comparisons were made between the ambient PM and three types of soil dust samples (agricultural soil, native soil, road dust) based on the particle size (fine vs. coarse), seasonality, and relative composition of 12 saccharide compounds. Based on the ambient concentrations of major saccharides and a number of other specific compounds (including elemental and organic carbon, ions, metals, alkanes, organic acids, and polycyclic aromatic hydrocarbons) that are simultaneously resolved in Higley PM samples, a Positive Matrix Factorization (PMF) model was performed to determine the key contributors to PM10 and PM2.5 levels. Six distinct factors were isolated, with two factors dominated by the enrichment of saccharide compounds. There was not consistency between the source profiles of these two saccharide rich source factors with the saccharide composition of the local size-segregated soil samples, which implies that there may be other major sources contributing to ambient PM saccharides. One possible alternative is that PBAPs that are injected directly into the atmosphere instead of residing in the surface soil and being re-entrained through soil erosion or agricultural processing. To our knowledge, this study is the first of its kind to compare the saccharide composition between the fine and coarse fraction of different soils types in two seasons, and to relate the contribution from soil dust to ambient PM using saccharide species.

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