Biogeochemical sustainability of semi-natural ecosystem

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The research is based on the novelty balance approach to the migration of artificial matter between biotic levels of an ecosystem and inanimate matter. *The Geochemical transition factor (GTF)* that represents the quantity of substance accumulated by plants from the area unit has been utilized for balance calculations. The temporal dinamics of GTF, permiting to asses the intensity of *biogeochemical flux,* suggested as volume of substance transferring during the time unit through the area unit of conditioned interface between abiotic and biotic levels.

In meadow ecosystem the only 10^{-5}–10^{-3} part of artificial contaminants is involved to biogeochemical cycling. The conciderably greater part accumulates in living matter of forest ecosystem: up to 50% of ^{14}C (Fig. 1), 10% of ^{3}H, 20% of ^{90}Sr, 13% of ^{137}Cs, 3% of ^{241}Am, 6% of Zn, 1% of Al and Ni, and less than 1% of Fe, Mn, and Cu. Artificial radionuclides and heavy metals are strongly accumulated in bottom deposits of aqueous ecosystem: anomalies of contamiation are closely localized to the pollution source. Accumulation of ^{14}C by micelium from irradiateted graphite is 50-100 times less than from sucrose solution in check experiment.
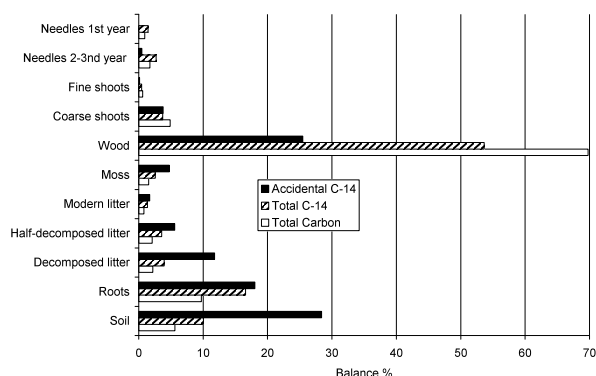

Figure 1. Distrubution of Carbon isotopes in pine ecosystem

The insignificant part of artificial matter involved to biogeochemical cycling determines the environmental capacity to contamination. Experience of geoecological investigations gives rise to conclusion about comparative sustainability of ecosystems in spite of the catastrophic increase of artificial loading.

Compact representation of complex organic aerosol processes

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Myriad organic compounds constitute organic aerosol (OA), tightly interconnecting multiphase chemistry, phase partitioning equilibria, and mass-transfer dynamics. Representations range from bare-minimum simplicity (e.g. emitting 12.5% of all terpenes as non-volatile, non-reactive, water-soluble organic aerosol) to maximal complexity (explicitly representing the multiphase chemistry and phase partitioning of millions of compounds). We favor a middle ground, grouping organic compounds in a property-based space that is directly tied to both vial physical properties as well as observable characteristics of ambient and lab-generated organic particles. This is the volatility basis set.

The first incarnation followed a single property – volatility – expressed in terms of a saturation mass concentration and typically lumping compounds into bins separated by factors of 10 in a logarithmic space. The 1D-VBS can precisely describe ideal phase partitioning over as many orders of magnitue as the number of bins. It can thus span the complete range of volatility relevant to atmospheric organics with 9 or so model compounds. It can also be used to fit chamber and dilution data to empirically constrain the volatility distribution of complex processes. It fosters insight into chemical evolution by forcing a mass balance. However, the single dimension suffers when confronted with non-ideal solutions as well as complex chemistry.

We have now added a second dimension, representing the oxidation of organics, to form a 2D-VBS. Oxidation state of bulk aerosol can be directly measured with advanced mass spectroscopy, and of course individual molecules can be located in this space as well. Oxidation in the atmosphere is irreversible, while volatility goes through a minimum as oxidation progresses. These fundamental behaviors are readily captured in the 2D-VBS.

As an illustration and test of OA evolution, a large team conducted the Multiple Chamber Aerosol Chemical Aging Study (MUCHACHAS) in 2008-2010 to observe the effects of OH radical "aging" on biogenic secondary organic aerosol (SOA). The effects were dramatic. They varied in different chambers, but a 2D-VBS model of the chemistry and chamber characteristics captures this variation using a predictive, previously published description of OA aging chemistry, showing that OA mass can double with aging. This aging chemistry must be included in transport models.