Earth's future and the role of science and government.

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The successes of 19th and 20th century developments in science, technology, medicine, agriculture, and engineering, coupled with economic and political developments, can be measured in terms of the change in expected human lifespan over this period. In 1990 the average lifespan was in the 40s, but by the year 2000, it had risen to around 70. However, with more children surviving into maturity and hence having children of their own, this produced a large increase in the human population, from 1.5 billion to 6 billion. The new challenges of the 21st century all derive from these successes of previous centuries. The population is likely to be 9 billion by 2050. Managing food, water, energy security, ecosystem services, disease and climate change for that number of people poses huge new challenges for science, technology and global governance.

Anaerobic metabolism and methane production in freshwater sediments: A model analysis of experimental data

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Increase in the atmospheric concentration of methane, a potent greenhouse gas, necessitates understanding biological controls and processes affecting its production, including the breakdown of organic matter in anoxic sediments. Freshwater wetlands are an important methane source, which has been estimated to account for ~20% of global emissions. In order to predict the effects of changing environmental conditions on methane production, increased insight into the cycling of organic carbon in benthic freshwater systems is needed.

Here, we present modeling results based on a detailed analysis of organic matter breakdown carried out on sediments collected in three freshwater habitats on the east coast of the USA. In the lab, timeseries of pore water constitutents in sediment slurries and radiotracer incubations using methanogenic precursors are used to delineate the process rates involved in anaerobic metabolism. Collectively, the data obtained contain a wealth of information on the step-wise breakdown of organic matter at the process level. To aid in data analysis, mathematical descriptions of organic matter breakdown are developed. In contrast to most studies that focus on the quantification of a single process (e.g. methanogenesis), simultaneous analysis of sequential and parallel occurring pathways in the benthic carbon cycle allows for an assessment of reaction rates constrained by the interplay among the different steps of anaerobic metabolism. By mining the measured radiotracer data and the accumulation/depletion of metabolites, the rates for the various processes involved in the conversion of organic macromolecules to CO_2 and CH_4 are elucidated. Further, time course data is used to quantify the kinetic rate parameters underlying the reaction network.

To delineate the effect of temperature on the production and ultimately the release of C_1 greenhouse gases from freshwater sediments, laboratory experiments performed at different temperatures are analyzed. The differential response of metabolic processes to temperature is used to identify biogeochemical bottlenecks and to understand the evolution of process rates as they adapt to changing climatic conditions.