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Earth's biogeochemical processes revealed by radiotracer-based activity measurement

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The biological fluxes on Earth are driven largely by microbial redox reactions. Microbial activity can sometimes demonstrate a recognizable level (e.g., fermentation), whereas most of the microbial processes show only a small effect on natural environment in the short term but have an impact on a longer time scale (i.e., over geological time scale). However the mechanisms regulating their operation and maintenance of elemental cycling on Earth remain poorly understood. In this regard, radioisotope tracer-based measurement is useful as a sensitive tool for the detection of microbial activity and related elemental cycling in the environment. This method can discriminate between assimilation and dissimilation processes based on the incorporation of radio-labelled substrate and excretion of the waste product from cells, respectively. Radiotracer-based analysis has been utilized since the early 1970's, and gone out of use with the development of molecular microbial ecology. Especially, microbial community genome sequencing (i.e., metagenomics) can provide less biased information of microbial community and function, which prompt further investigation of microbial ecosystem in extreme environment including deep subsurface and the outer space. These latest techniques will emphasize the importance of microbial activity measurement in extreme environment again. We have already started to evaluate the potential microbial activity of methane and acetate production, sulfate reduction, CO_2 uptake and organic matter mineralization in a deep-sea hydrothemal field, cold-seep and deep subsurface. The detection limit for each analytical method is above the level of nmol/L/day. Understanding these biogeochemical processes is crucially important to us as microbial life would globally catalyze and potentially provide environmental transformations.

Keywords: radiotracer, activity measurement, biogeochemical cycle