

Emergy of the Global Biogeochemical Cycles of Biologically Active Elements

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Accurate estimates of the emergy of elemental flows are needed to accurately evaluate the far field effects of anthropogenic wastes. The transformity and specific emergy of the elements and of their different chemical species is also needed to quantify the inputs to many production functions. In this study, we performed emergy evaluations of the biogeochemical cycles of the biologically active elements: carbon, nitrogen, sulfur, phosphorus, oxygen and silica. We assembled budgets for preindustrial and industrial global flows of the biologically active elements from the literature. The emergy basis for the elemental cycles was obtained by documenting the global inflows of renewable and nonrenewable emergy for preindustrial time (circa and 1850) and for the industrial age using a variable time window that covered the period of observation used to establish the elemental budgets in the industrial age. We calculated the transformities and specific emergies of the total flow of the elements and of particular chemical species of interest. The elemental cycles were diagramed in Energy Systems Language and tables of transformities and specific emergies were provided for use in subsequent emergy evaluations. Joint evaluation of the biologically active elements allowed us to examine these elemental cycles with respect to the commonalities and differences in their structure, function and potential impact. We characterize the coupling of these elements in terms of a fast biochemical loop and a slow geochemical loop determined from the process of diagramming the elemental cycles using the Energy Systems Language.

Keywords: global biogeochemical cycles; emergy evaluation; biologically active elements; carbon; nitrogen; sulfur; phosphorus; oxygen; silica