

The remediation of contaminated soil and groundwater is essential toward the development of a sustainable society. However, remediation activities at various stages will also inherently add a significant burden of environmental footprints. Green remediation is thus increasingly recognized in the recent years by various regulatory agencies, responsible parties, remediation engineers, and various other stakeholders. This paper critically analyzes the evolution of green remediation and its context relating to various driving forces and potential impediments, the primary practices and opportunities to an increased sustainability in site cleanups, and quantitative sustainability evaluation tools employed to measure the greenness of soil and groundwater remediation technologies. Although the principles of green remediation are supported by the goals of several regulatory provisions in the U.S. and EU countries, there are not sufficient regulatory driving force and economic incentives to fully implement green practice in the remediation industries. Even though the incorporation of green remediation into contaminant cleanup can provide a better image for the responsible party, the negative side from the public may also exist because of the perception of selection preference to the less invasive cleanup technology (e.g., natural attenuation over pump-and-treat). The problems associated with the currently employed tools using life cycle assessment (LCA) also prevent the accurate comparison among various remedial options essential for the decision-makers. Lessons learned from several recent case studies on LCA are summarized in regard to its methodological flaws, such as subjective selection of functional units and impact categories, and inconsistent spatial and temporal boundaries. Current LCA methodology well quantified remediation options in the regional and global scale such as eutrophication, ozone depletion and global warming; however, with inherent issues of quantification and weighting, sitespecific primary impacts of contaminated sites are often underestimated, which are often the driving force for site cleanups. A remediation sustainability index is proposed in the context of six core elements of green remediation. Finally, the opportunities, challenges and some future perspective for the incorporation of sustainable principles into the practice of cleaning up contaminated sites are discussed in the paper.