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# Eutrophication control using natural geo-engineering materials: harvesting nutrients for integrated Water-Energy-Food (iWEF) products

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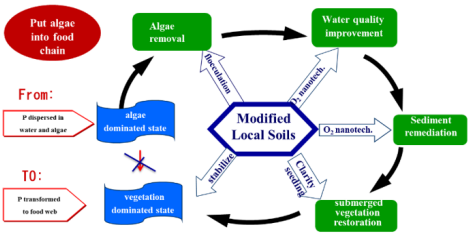
Terrestrial phosphorus run off to natural waters can cause aquatic ecological destruction (e.g. eutrophication and harmful algal blooms (HABs)) and crisis of fertilizers for food shortage. New integrated technologies are important for breakthrough in remediation efficiency/cost and sustainability of phosphorus resources. A combined strategy of in-situ (Fig 1) and ex-situ (Fig. 2) methods are developed to meet these targets.

For the in-situ technical system, oxygen nanobubble modified local soil materials can be delivered into lakes and coastal waters through mechanical (ships and planes) or natural means (e.g. rivers) in order to remove the HABs and remediate hypoxic or anoxic sediments to reduce the release of internal pollutants, and for the restoration of macrophyte and biodiversity. By changing the physical, chemical and microbial processes at the sediment-water interface, oxygen nanobubbles provide a sustainable in-situ means through which to manipulate the fluxes of nutrients (N, P) and greenhouse gases (C) as well as the speciation of metals (As, Hg) at the sediment-water interfaces. The water and sediment environment change caused by the in-situ technology will lead to the long-term ecological restoration in shallow water system.

Fig. 1. Multi-disciplinary principle of MLS technology (Water 2019, 11 (6): 1123 and references there in)

For the ex-situ technical system, a flocculation-flotation method is developed to harvest the algal blooms and the nutrients in water column and return them to the land, where the harvested algal cells are used for industrial wastewater treatment, production of agricultural fertilizers and soil improvers (e.g. algal hydro-biochar), and green energies such as biofuel and electricity. The technical framework to turn harmful algal blooms into societally needed products is essential for the commercialization of the remediation technologies in terms of sustainability, cost-efficiency and low carbon aspects, which may impact on the green policies of local governments.

Fig. 2. iWEF technical framework for sustainable environmental circular economy

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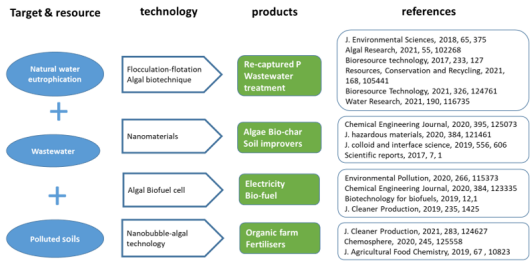


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