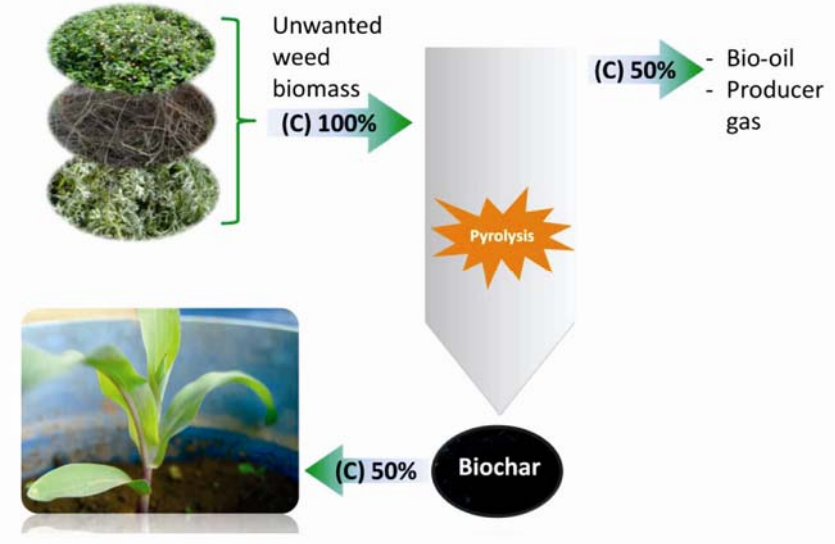

Figure 1. Biochar carbon cycle[2].

23% and 48% from different weed and forestry biomass. Considering productivity of 12 t ha^{-1} of weed biomass annually, 1.8 t ha^{-1} of organic carbon {12 × 0.25 (25% biochar productivity) × 0.6 (50% organic carbon in biochar)} can be sequestered in the soil annually. Another 50% of the carbon can be utilized to produce renewable energy through converting the flue gas to bio-oil and synthetic gas enriched with H_2 and CH_4. NE India has the potential to produce 37 mt of agricultural waste biomass. If only 1% of this biomass is converted to biochar, about 74,000 t of carbon can be sequestered annually. If 1% of the process of producing biochar is carried out through modern equipments, about 1300 and 900 t of bio-oil and biogas can be produced respectively, which is equivalent to 31 terajoule of energy.

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S. MANDAL*
G. I. RAMKRUSHNA
B. C. VERMA
ANUP DAS

ICAR Research Complex for NEH Region,
Umiam 793 103, India
**e-mail: smandal2604@gmail.com*

Phytotechnological applications of 'phoomdi', Loktak lake, Manipur, Northeast India

Loktak lake (93°46′–93°55′E, 24°25′–24°42′N), a floodplain wetland of Manipur river, is the largest freshwater lake in Northeast India (Figure 1 *a*). The lake covers an area of 287 sq. km and is fed by 36 streams[1]. Presence of floating vegetation or island, locally known as 'phoomdi' is a unique feature of Loktak lake (Figure 1 *b* and *c*). Phoomdi is a heterogenous mass of soil, vegetation and organic matter in different stages of decay, which floats over a vast expanse of the free water. It occurs in various sizes and thicknesses, occupying almost half the surface area of the lake[2].

Phoomdi acts as natural habitat for a wide variety of fauna, viz. 81 species of birds, 25 species of reptiles, 6 species of amphibians and 22 species of mammals[1]. It provides various bio-products, viz. wild edible, medicine, fodder, fuel, handicrafts and house-making materials for the local communities. 'Athaphoom' or floating pond fishing in Loktak lake is the only means of sustenance for fishermen who depend solely on fishery[2].

At present, the lake is facing serious ecological problems, viz. cultural eutrophication, siltation and pollution. This has resulted into uncontrolled proliferation of phoomdi in the lake area. Construction of Ithai barrage on Manipur river for power generation (Loktak Multipurpose project – 1983) in the energy-starved state of Manipur and degradation of catchment areas proved to be the reasons for the disturbed ecosystem[2]. It has threatened the fragile freshwater ecosystem of the lake, resulting into its inclusion in the Montreux records (1993) by the Ramsar Convention[1]. This has severely decreased the population of many rooted floating plant species, viz. *Trapa natans*, *Euryale ferox*, *Nelumbo* sp. and *Nymphaea* sp. and led to the disappearance of migratory fishes and waterfowls from Loktak lake[3].

In order to control and manage the proliferating phoomdi manually, dredgers are used by the governing bodies (Loktak Development Authority and the

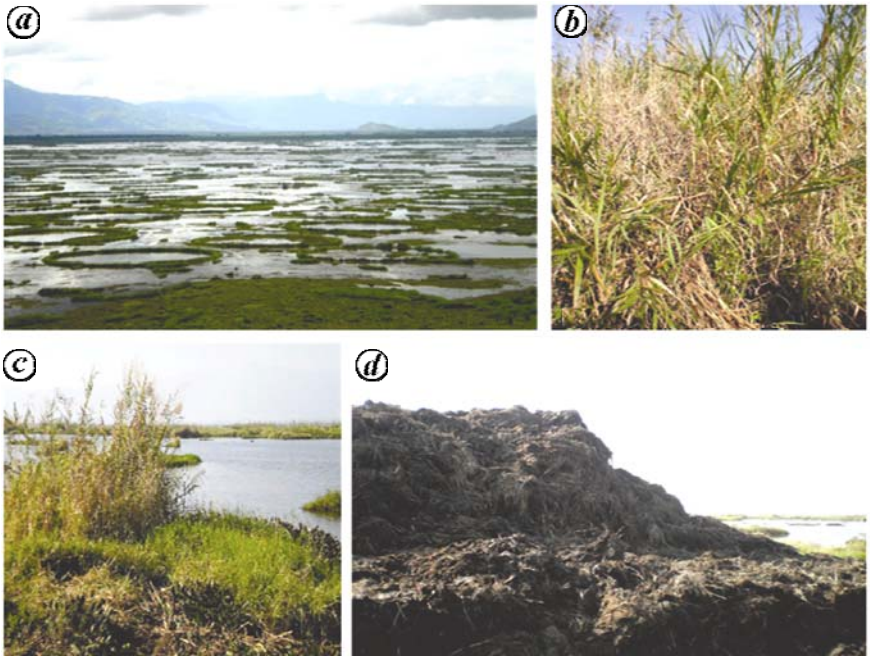

Figure 1. ***a***, Loktak lake, Northeast India and the floating *phoomdi*. ***b***, *Phragmites karka*, a dominant *phoomdi* species. ***c***, Luxuriant *phoomdi* growth. ***d***, Heaps of *phoomdi* on the shores of Loktak lake.

Forest Department) to pull out the biomass from the lake and dispose it without addressing its applicability (Figure 1 *d*). This has destroyed the habitat of many plant species which are edible, have medicinal value used as fodder or fuel, and have cultural significances. In addition, it has threatened the sustenance of the communities dependent on athaphoom fishing and collection of wild edibles for trade as their means of livelihood.

Recently, biosorption studies using low-cost, effective and environment-friendly biosorbents have gained attention regarding their role in cleaning wastewater environment contaminated with various heavy metals, viz. As, Cr, Cd, Cu, Hg, Mn, Mg, Ni, Pb and Zn[4–7]. Heavy metals discharged from various anthropogenic and technogenic sources into the aquatic system pose a threat to the biota as well as human health[4]. A variety of adsorbents such as charcoal, peanut hulls, rice husk, rubber, oil palm leaf, wheat straw, coffee and tea waste, have been studied for the removal of heavy metals from wastewater[5–7]. Identification of aquatic plants available in the phoomdi of Loktak lake, with potential for heavy-metal removal from aqueous environment may provide an additional application to the unused biomass.

Spirodela polyrhiza (L.) Schleiden biomass from the phoomdi of Loktak lake was studied as an adsorbent for Pb(II) and Cd(II) removal from aqueous solution[4]. *S. polyrhiza* is a free-floating aquatic plant of the family Araceae that has wide geographic distribution[8]. It helps in the initial phoomdi formation and is abundant in the lake water. Adsorption experiments were carried out to describe the effects of pH, adsorbent dosage, contact time, initial metal concentration and temperature on the metal-removal process. The results showed effective adsorption of Pb(II) and Cd(II) onto the plant biomass with maximum adsorption capacity of 137 and 36.0 mg g^{-1} respectively, at optimum pH of 4.0 and 6.0, contact time of 120 min, and temperature of 20°C. On the basis of the present findings, it can be concluded that *S. polyrhiza* biomass can be used as a low-cost, effective adsorbent of Pb(II) and Cd(II) from wastewater environment[4].

The study provided an additional application of the phoomdi species, which will be dredged out and discarded on the lake shore. With a total of nearly 128 plant species spreading across 287 sq. km area[1,2], the huge floating phoomdi biomass of Loktak lake can provide potential adsorbents for various heavy metals, which can be used for metal removal from wastewater environment.

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MAIBAM DHANARAJ MEITEI
M. N. V. PRASAD*

Department of Plant Sciences,
University of Hyderabad,
Hyderabad 500 046, India
**e-mail: prasad_mnv@yahoo.com*