# Arsenic contamination – a societal issue

Arsenic (As) contamination is problematic not only as a health hazard but also as a social problem worldwide. Besides arsenic toxicity and arsenicosis, arsenic poisoning results in extensive social implications for the victims and their families in the affected areas[1].

A dangerous trend is developing in As-affected areas with increasing disconnect of the affected people from the scientific community. During our visit to Nawalparasi district (Terai Region), Nepal, to collect As-containing samples, we observed that many of the residents refused to share their information regarding As-contamination and its toxicity. They blamed the scientific community of being selfish (only wanting to publish papers) and not doing anything to help those affected. The residents confessed that they faced social stigma. Furthermore, majority of the arsenicosis patients did not receive any treatment due to financial constrains.

Although many government bodies, national and international non-government organizations are working for mitigation of As-contamination in Nawalparasi, concurrent measures are still lacking. As filters are being distributed by several agencies (UNICEF Nepal and Filters for Family, a local INGO), but they are not reaching the needy.

It needs to be re-emphasized that raising public awareness on As contamination and related health problems is largely a societal issue. One has to overcome the obstacles mentioned above to make a public awareness campaign successful.

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ISHWAR CHANDRA YADAV
SURENDRA SINGH*

*Centre of Advanced Study in Botany,*
*Banaras Hindu University,*
*Varanasi 221 005, India*
**e-mail: surendrasingh.bhu@gmail.com*

# Biochar: an innovative soil ameliorant for climate change mitigation in NE India

Long-duration storage of carbon in the soil has been considered as an important method to mitigate increasing levels of carbon dioxide ($CO_2$) concentration in the atmosphere[1]. From the primitive technology of Amazonians known as 'Terra-Preta' for enhancing soil productivity with charred biomass, biochar has emerged as a viable soil ameliorant for carbon sequestration. Biochar is a carbon-rich material produced by incomplete combustion of biological materials in the absence of oxygen or with limited amount of oxygen. It is reported that biochar stores carbon (C) in the soil for hundreds to thousands of years and thus, the level of greenhouse gases (GHGs) like $CO_2$ and $CH_4$ can be reduced significantly from the atmosphere[2]. Biochar production by pyrolysis process from different crop residues and application in the soil had been proposed by many researchers as an effective countermeasure to increase soil organic carbon stock while improving soil fertility and climate change mitigation in agriculture[3]. High recalcitrance of biochar against microbial decay had indirect effect on increased nitrogen (N) use efficiency of crops which might reduce GHG emission from N fertilizer industry[4].

Biological carbon cycle involves two major processes – photosynthesis and respiration. In photosynthesis, plants absorb atmospheric $CO_2$ and produce biological mass and in respiration biomass is converted to $CO_2$. Production of $CO_2$ is also largely contributed by decomposition of dead plant cell and fire. In undisturbed forest ecosystem, the cycle of uptake of C by photosynthesis and release by decay is balanced[5]. This balance is disturbed when fuel and biomass are completely burnt causing a sudden release of huge amount of C, which took thousands of years to accumulate, in the form of $CO_2$ and other C-compounds in the atmosphere.

The manipulated carbon cycle due to biochar carbon sequestration and carbon negative energy production is shown in Figure 1. Biochar being a pure form of carbon does not decompose easily and remains in the soil for thousands of years. Thus, pyrolysis of biomass can transfer 50% of the carbon stored in the plant tissue from active to inactive carbon pool. The remaining 50% of carbon can be used to produce energy and fuels. This enables carbon negative energy generation if re-growing resources are used, i.e. with each unit of energy produced $CO_2$ is removed from the atmosphere[5]. With the use of this simple technology 2.2 gigatons of carbon can be stored annually worldwide by 2050 (ref. 6).

Biochar from wood is not a feasible and sustainable option in most farming situations of India. However, biochar can be produced by incomplete combustion from any ligno-cellulosic biomass and is a by-product of modern technologies for bioenergy production such as gasification and pyrolysis. Therefore, crop residues could be used to produce energy, and the biochar by-product could serve to recycle nutrients and improve soil fertility[7]. Agricultural waste and weed biomass are alternative ways to produce biochar directly or as a by-product of bioenergy industry depending on the biomass.

Biochar has been produced from different crop residues and their effects on soil properties and crop productivity have been studied by many researchers. These studies showed improvement of soil pH, Citation Exchange Capacity (CEC), increased nutrient use efficiency by plants and crop yield. In high-rainfall areas of North East (NE) India, weed biomass growth of approximately 12 t $ha^{-1}$ has been reported annually[8]. The study showed biochar productivity between

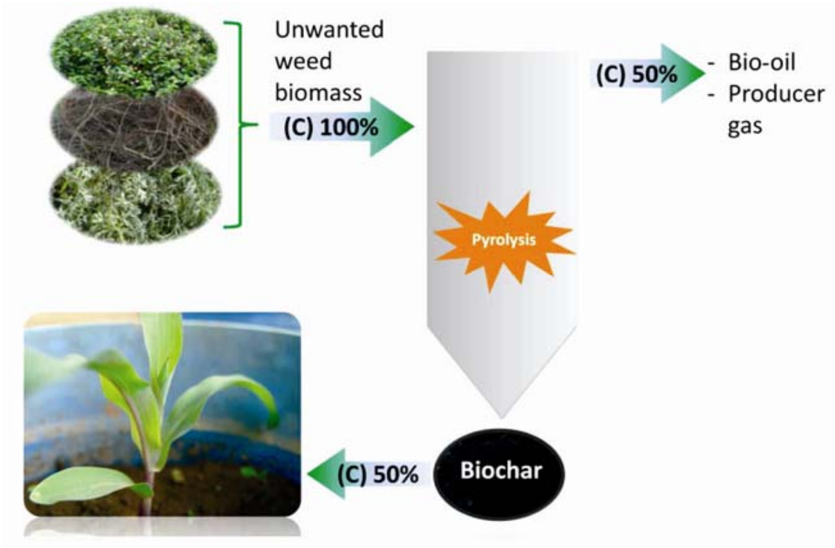


**Figure 1.** Biochar carbon cycle[2].

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