develops can easily buffer soil acidity (as does organic matter). Generally landholders/farmers apply biochar in their own field only by hand. Considering human health, due to prolonged contact with airborne biochar particulates, it is not viable on a large scale. Deposition of biochar directly into the rhizosphere is a more suitable method of application. Mixing of biochar with compost, manure and other organic inputs will reduce odour and also improve nutrient availability over time due to slower leaching rate. Mixtures may be applied for uniform topsoil mixing without incorporation[3].

Till date, there is no specific rate of application of biochar in the soil. It depends on many factors such as biomass type used, type and proportion of nutrients (N, P, K, etc.), climatic and topographic factors of the land, and degree of metal contamination in the biomass. It has been found that application of biochar 5–10 t/ha, i.e. 0.5–1 kg/m^2 is a better option. Assuming that biochar is rich in nutrients, even low rates of biochar application can significantly increase crop productivity. In conclusion, in view of the unique property of biochar, it may serve as an important tool for agricultural researchers to mitigate climate change. It may be explored as an example of how a lesser important waste material that is produced as a by-product of burning of fuel can benefit the agricultural system through scientific technology.

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Need for phytolith-occluded carbon research in India

Mitigation of climate change is a human intervention aimed at reducing the sources or enhancing the sinks of greenhouse gases. Developing technologies to reduce the rate of increase in the atmospheric concentration of carbon dioxide (CO_2) from annual emissions of 11 Pg C yr^{-1} from energy, process industry, land-use conversion and soil cultivation is an important issue of the 21st century[1]. The ability of biotic sequestration and especially terrestrial systems to sequester and store atmospheric CO_2 has been recognized as an effective and low cost method of offsetting carbon emissions. Among the most promising approaches of long-term atmospheric CO_2 sequestration is terrestrial biogeochemical carbon sequestration[2,3]. Phytoliths, also referred to as plant opal, are silicified features that form as a result of biomineralization within plants[4]. They are present in most plants and range in concentration from 0.5% or less in most dicotyledons, 1–3% in typical dry land grasses, and 10–15% in Cyperaceae, and different species of Poaceae, including bamboos[2,5]. Recent studies have revealed that phytoliths contain 0.2–5.8% of phytolith-occluded carbon (PhytOC)[4,6–8], are highly resistant against decomposition and may accumulate in the soil as a fraction of soil organic matter (SOM) for several thousands of years after plant decomposition[4], demonstrating the potential of phytoliths in the long-term biogeochemical sequestration of atmospheric CO_2. Therefore, bio-mineralization of silicophytoliths is an important process as it influences the earth carbon cycle by occlusion of carbon during the silicification process[9].

Keeping in view the high concentration of phytoliths in certain herbaceous grass and woody bamboo species reported from China and elsewhere[2,8,10], a similar work can be initiated in India. In the Indian context, bamboo (Poaceae: Bambuseae) with 136 different species[11] dominates forests as wet, moist and secondary moist bamboo brakes[12] and covers 2.25% of total geographical area (TGA) of the country[13]. On the other hand, with 15 different grassland types, grasslands cover an area of 92,300 km^2 (3% of TGA) in India[13]. Bamboo forests and grasslands together represent ~5% of TGA of the country, and therefore this vast geographical area can form an important terrestrial landscape for PhytOC sequestration and management. Very little, if any, research in this direction has been carried out to explore phytolith concentration and PhytOC stock in bamboo forests and grasslands in India. Realizing the fact that all the species do not have high potential for phytolith concentration and therefore PhytOC stock, it is the need of the hour to identify potential species of herbaceous grasses as well as woody bamboo species. Identification of high phytolith content species will enable us to manage terrestrial ecosystems with such species to enhance PhytOC sequestration to set-in-motion the mitigation of climate change through removal of atmospheric CO_2 in a cost-effective manner. Furthermore, development of management strategies to increase production of PhytOC from the identified species will further advance the climate change mitigation programmes. However, there emerges a point that preponderance of only those species with high concentration of phytoliths can alter the spectrum of natural biodiversity and undervalue the possible benefits that can be offered by low-concentration phytolith species. Many of these environmental concerns and especially biodiversity conservation can be avoided without affecting structure and function of other terrestrial ecosystems by promoting high phytolith species as planting material for (i) reclamation of degraded lands and river banks, (ii) established and newly constructed road and railway tracks, etc.

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Time to publish: the scientific efficiency of nations

Using the simple arithmetical rule of three, I had earlier computed the time it takes for an average scientist to publish a paper[1]. This is a simple proxy for measuring the scientific efficiency of the R&D workforce of a country. The latest UNESCO Science Report[2] gives the number of full-time researchers deployed by a country per million of its population (say *S* scientists/million), and also the number of peer-reviewed scientific papers (i.e. articles, reviews and notes only) indexed in the *Web of Science* database from Thomson Reuters published per million per year (say *P* papers/million/yr). The ratio $TtP = S/P$ has the curious units: years/paper/scientist. *TtP* therefore measures the average number of years a scientist takes to publish a paper.

Table 1 gives a comparison of some leading countries in scientific R&D. Figure 1 displays this graphically.

Table 1. The number of years it takes for an average scientist to publish a paper

Country	Researchers/million inhabitants (2013)[a]	Papers/million inhabitants (2014)[b]	Time to publish
Switzerland	4495	3102	1.45
Australia	4335	1974	2.20
South Africa	408	175	2.33
Sweden	6509	2269	2.87
Canada	4494	1538	2.92
United Kingdom	4108	1385	2.97
Singapore	6438	1913	3.37
Finland	7223	1976	3.66
India	160	42	3.81
Brazil	710	184	3.86
Germany	4355	1109	3.93
United States of America	3984	998	3.99
France	4125	1007	4.10
China	1071	184	5.82
Israel	8337	1431	5.83
South Korea	6533	1015	6.44
Japan	5195	576	9.02
Russia	3085	204	15.12

[a]Researchers per million people (from table S6 of the UNESCO Science Report[2]).
[b]Papers/million inhabitants (from table S8 of the UNESCO Science Report[2]).

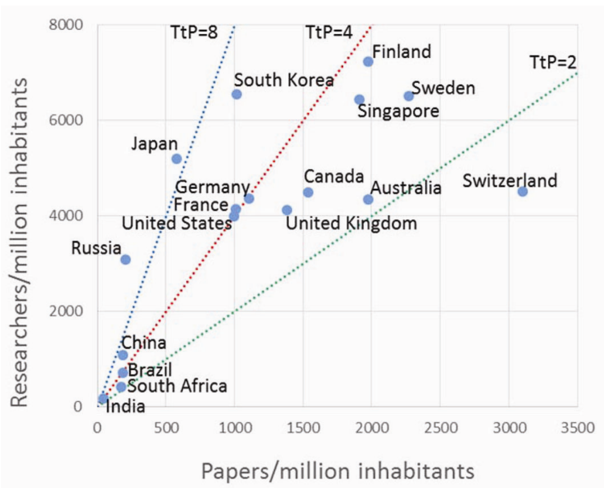

Figure 1. The number of years it takes for an average scientist to publish a paper.

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