Soil degradation

Two papers in a Special Section of *Current Science*[1,2] deal with the problem of degradation in some Vertisols of the Deccan Plateau. These are indeed original research findings of the authors. The degradation has been explained as an outcome of selective removal of calcium from exchange complex in the upper strata of the soil profile and its replacement by sodium ion released by weathering of certain minerals. The process is mediated by rainwater that percolates down the soil profile. However, to the best of my knowledge, such a phenomenon is not obvious in numerous other soils of the vast semi-arid tropical soil (SAT) in the country. This is possibly so, because though leaching of free calcium carbonate and to an extent also of calcium on exchange complex possibly does happen, there is addition of calcium from weathering of minerals such as plagioclase and others, and from biogenic recycling. This does not cause the problem of sodicity that is manifest in Vertisols studied by the authors. It seems more appropriate to consider the genesis of sodicity problem in Vertisols as an outcome of mineralogical make-up, rather than a climate-induced process as has been suggested in the two papers under reference.

1. Pal, D. K. *et al.*, *Curr. Sci.*, 2016, **110**(9), 1675–1682.
2. Bhattacharyya, T. *et al.*, *Curr. Sci.*, 2016, **110**(9), 1784–1788.

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Response:

Although pedogenic processes responsible for the formation of sodic soils have been described in detail in our paper[1] based on research results obtained, we explain further for a better understanding on the impossibility of leaching of free $CaCO_3$ in soils, as it is not a recognized pedogenic process in soil science. SAT soils show the presence of pedogenic $CaCO_3$ (PC) and non-pedogenic $CaCO_3$ (NPC). NPC is pedorelict, while PC is common in major soil types of India[2]. Under SAT environments, water loss through evapotranspiration is considered to be the primary mechanism in the precipitation of PC, while temperature controls the water flow in the soil[3]. PC creates unfavourable physical conditions, caused by concomitant development of exchangeable sodium per cent (ESP)[4]. PC in soils with restricted leaching is formed only when the soil solution is supersaturated with $CaCO_3$ in the semiarid environments[5]. This particular pedogenetic process of PC formation suggests that climatic aridity has an important role in the accumulation of carbonates in soils. In SAT Vertisols of Peninsular India, chemical weathering of primary minerals is not substantial, as evidenced from the presence of either fresh or weakly to moderately altered plagioclase and micas. Therefore, the state of mineral weathering discounts the formation of smectite during the development of Vertisols[6] and thus validates the hypothesis that Vertisol formation in SAT environment reflects a positive entropy change. Dissolution of NPC and recrystallization of dissolved Ca^{2+} ions are responsible for the formation of PCs that enhances the pH (~8.2 to >8.5), and also the relative abundance of Na^+ ions at soil exchange sites and in the solution. The Na^+ ions in turn cause dispersion of the fine clay particles. The dispersed fine clay particles translocate in the soils as the formation of PC creates a Na^+-enriched chemical environment conducive for deflocculation of clay particles and their subsequent movement downwards. The formation of PC and clay illuviation are thus two concurrent and contemporary pedogenetic events, which result in increase in sodium adsorption ratio, and ESP and pH with depth[7]. Therefore, it is clear that the downward movement of $CaCO_3$ as such does not take place. These pedogenetic processes clearly suggest that the formation of PC is a basic natural chemical degradation process[2], induced by linked tectonics–climate events[8], which exhibit regressive pedogenesis[3]; they also immobilize soil carbon in unavailable form. Therefore, we uphold the view that sodicity problem in non-irrigated SAT soils is a climatically induced natural degradation process.

1. Pal, D. K. *et al.*, *Curr. Sci.*, 2016, **110**(9), 1675–1682.
2. Pal, D. K., Dasog, G. S., Vadivelu, S., Ahuja, R. L. and Bhattacharyya, T., In *Global Climate Change and Pedogenic Carbonates* (eds Lal, R. *et al.*), Lewis Publishers, USA, 2000, pp. 149–185.
3. Pal, D. K., Sarkar, D., Bhattacharyya, T., Datta, S. C., Chandran, P. and Ray, S. K., In *Climate Change and Agriculture* (eds Bhattacharyya, T. *et al.*), Studium Press, New Delhi, 2013, pp. 113–121.
4. Pal, D. K., Bhattacharyya, T. and Wani, S. P., In *World Soil Resources* (eds Lal, R. and Stewart, B. A.), Francis and Taylor, Boca Raton, Florida, 2012, pp. 317–343.
5. Pal, D. K., Wani, S. P., Sahrawat, K. L. and Srivastava, P., *Catena*, 2014, **121**, 260–278; doi:10.1016/j.catena2014.05.023.
6. Srivastava, P., Bhattacharyya, T. and Pal, D. K., *Clays Clay Min.*, 2002, **50**, 111–126.
7. Pal, D. K., Srivastava, P., Durge, S. L. and Bhattacharyya, T., *Catena*, 2003, **51**, 3–31.
8. Pal, D. K., Bhattacharyya, T., Chandran, P. and Ray, S. K., In *Rainfed Agriculture: Unlocking the Potential* (eds Wani, S. P. *et al.*), CAB International Publishing, Oxfordshire, 2009, pp. 54–72.

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