Termites as ecosystem engineers and potentials for soil restoration

Kachchh, the 2nd largest district in India (45,652 km^2) and located in the northwestern region of Gujarat, experiences tropical arid climate (13 average rainy days in a year) with high evapotranspiration rate[1] resulting in degradation of land. Higher dependence on groundwater for agricultural and industrial activities has accelerated the salinity ingression, as the district shares its boundary with the Gulf of Kachchh from three directions. This type of salinity ingression is seen in Banni region in particular, which is infested by exotics such as *Prosopis juliflora*[2]. Further, expansion of crusted soils, a result of higher accumulation of Na ions[3], one of the prime chemical constituents in Banni soils in Kachchh, is a major problem in agricultural lands of this district. Low infiltration capacity of crusted soils results in increased surface runoff and further aggravates the problem of groundwater recharge. Thus, rehabilitation of crusted soils is required to reduce runoff from affected areas. No rehabilitation effort has been made for crusted soils in the Kachchh region barring efforts that contemplate increasing nutrient status of soils in the form of increased application of agro-inputs such as organic manure and vermicompost at individual level. However, rehabilitation has to be accelerated, economically affordable, cheap and easily accessible for sustainable land management. Increasingly, it is being recognized globally that termites are an important component of agro-ecosystems, particularly in developing economies, where they are an alternative to expensive agro-inputs. Termite-mediated processes are used to improve the soil–water balance.

Termites, one of the highly successful groups of social insects, coevolving for over 300 million years and constituting an integral component of the ecosystem, are successful in invading new habitats. Due to their wide range of distribution across the world, termites have severely disrupted the ecological system causing considerable economic damage. Nevertheless, they are the most important soil fauna in the semi-arid tropics as they bring about significant physical and chemical modifications in soils[4]. They are known to play an important role in detritus decomposition and maintaining soil structure[5] thereby modifying soil chemical characteristics as a result of upturn of soil. Termites can be used and managed, together with locally available organic resources, to counteract land degradation. The soil crust is destroyed by the galleries dug by the termites. Three types of burrows are seen: type 1 burrows which are subsurface ones, type 2 burrows which are channels and type 3 burrows which result from the construction of the nests[6].

In arid and semi-arid regions of India, predominantly in the Kachchh region, so far termite-mediated processes have not been used in land management, particularly soil rehabilitation. It seems that termite activity can be triggered by application of various mulches to the crusted soil surface. Their bioturbating activities accelerate the soil rehabilitation process by (i) breaking up of surface crusts, (ii) reducing soil compaction, (iii) increasing soil porosity, (iv) improving water infiltration into the soil and (v) enhancing water holding capacity of the soil, thereby reducing surface runoff. These activities are conducive for (a) root penetration, (b) vegetative cover regeneration and (c) primary productivity restoration. Termites improve vegetation growth first by improving certain physical properties of soil (soil structure, water infiltration and water storage capacity, and soil rootability[7]) and second by improving the chemical cycling in soil (nutrient release from the mulch into the soil). In semi-arid conditions, termites play a key role in nutrient cycling, especially through comminution and the turn-over of organic material[8], both processes being critical for land rehabilitation.

Use of termites for land rehabilitation is an ecologically sustainable approach as it requires only an initial investment in organic matter. Tillage is an unsustainable mechanical method in controlling crusting as a few rainfalls result in building up of a new crust[9]. An increasing number of researchers show interest not only in taxonomic details of these insects, but their role as ecological engineers is also on the rise due to increased recognition of the role of these lesser known soil invertebrates in rehabilitation. Future research questions on a diversified eco-agricultural gradient should be on the role of termites in increasing the carbon sequestration potential of soils in view of the recent deliberations in Copenhagen and elsewhere. Bearing the local scenario in mind, the response of termites on usage of *Prosopis* plant parts for the purpose of mulching would help enhance soil quality and also contain the problem of *Prosopis* invasion. Understanding the role of these species in restoring saline grasslands of Kachchh, for which it is renowned, would provide a solution in controlling the land degradation and pave ways for maintaining the ecological sustainability in the region.

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Physics and India

I read with interest reviews of two books in *Current Science*[1]. These are, in reverse order, *Remembering Sir J. C. Bose* and *India in the World of Physics: Then and Now*.

Acharya Jagadish Chandra Bose made remarkable contributions in the field of semiconductors which are only lightly touched upon in the chapter devoted to 'Millimetre wave researches of Bose'. His 1904 patent is mentioned now in many textbooks in physics[2] along with the fact that metal-semiconductor rectifiers were discovered way back in 1874 by Ferdinand Braun, who used mercury as the metal and galena (PbS) as the semiconductor. It is often forgotten that Marconi shared the 1909 Nobel Prize with Braun 'for their development of wireless telegraphy'. Braun also demonstrated the propagation of radio waves in his laboratory. However, Bose was the first to generate millimetre waves, whose importance was realized much later, and also to demonstrate their quasi-optical properties. These millimetre waves, which propagated in straight lines, obviously could not cross the Atlantic and make the sensation created by Marconi and his team.

Bose studied the behaviour of a variety of metals on different types of galena and thus discovered that the polarity of rectification depended on the type of metal and galena. He thus used the terms positive and negative coherers which were later understood to be n- and p-type galena. Shyamadas Chatterjee who worked at the Bose Institute in the early forties discussed these results with Neville Mott when he visited the Cavendish Laboratory in the mid-fifties. Mott was struck by these observations which led to him to make the oft-quoted remark that 'Bose was sixty years ahead of his time!' This incident was narrated to me by Chatterjee shortly after his visit and is a mark of recognition of Bose's research by one of the doyens of the field.

This brings me to the subject of the other book *India in the World of Physics: Then and Now*. It was while working at the Bose Institute that Chatterjee discovered in 1940 the spontaneous fission of uranium, which must rank as one of the major experimental findings in India. I wonder whether this has been mentioned in the above volume. Working almost single-handed with a simple neutron source, he set-up an experiment with completely indigenous apparatus to study the newly reported uranium fission when it was bombarded with neutrons. In the process, he found that distinct counts were recorded by the detector even without the presence of the neutron source. He was puzzled by this observation, because he had taken precautions to shield the uranium sample and the detector from cosmic rays. He reported the phenomenon to S. N. Bose, who quickly arrived at the conclusion that this must be due to spontaneous fission of uranium. The half-life was calculated with the help of N. R. Sen, Head of the Department of the Applied Mathematics, a friend and contemporary of Bose. This was found to be about 4.5×10^9 years, at least an order of magnitude less than the value calculated by Teller *et al.* I have narrated the incident in a brief article in the recently published biography of S. N. Bose[3] and also earlier in the obituary of Chatterjee[4].

The phenomenon was discovered simultaneously by Georgii Flerov and Konstantin Petrazhak in the Soviet Union who verified Chatterjee's value of the half-life[5]. Their paper titled 'Spontaneous fission of uranium' addressed isotopes U-238, U-235 and U-234 and the observation of the first occurrence of spontaneous fission. Chatterjee published his work later in an Indian journal and was recognized by the Russian authors, who presented him an inscribed copy of their book on the subject. He was also one of the first few in the country to set up a Wilson Cloud Chamber in 1938 and also pioneered radio-carbon dating.

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