Reclamation of mill tailings

The last paragraph of J. V. Subbaraman's letter (*Curr. Sci.*, 2001, **81**, 631–632) makes sad reading. In this era of rapid scientific advancements, it is out of place to concede defeat to environmental hazards created by man. Environmental restoration, particularly reclamation of tailings of mining activity, is in vogue for almost four decades[1] and has been given an exhaustive scientific base in 1981 by Bradshaw, Liverpool University[2].

When methods for stabilization of tailings are well known, we should be trying to go a step further and make the tailing dumps productive, especially since the Kolar gold mill tailings do not appear to be toxic according to table 1 of the letter cited above. Even for toxic tailings, monitoring the quality of plants grown on it is advised, to decide their consumption by cattle. I have seen cattle grazing on grass cultivated for stabilization of lead–zinc mine tailings in Derbyshire in the UK, where safety of cattle was ensured by manipulating rotational grazing practice.

Grass planted for successful stabilization on zinc–lead mine tailings in Zawar in Rajasthan was found to accumulate the same metals in measurable concentrations[3]. Hence we recommended 'no access' to cattle there, since we were told that the prescribed rotational grazing may not be adhered to by the local cattle-keepers. Experimentally-grown *bajra* on these tailings was found to concentrate heavy metals in the grains. Finally, we recommended the use of grass-stabilized tailings area for sports and other recreational activity that did not involve consumption of the produce.

No doubt, every environmental restoration activity has its own price tag. Cost-cutting is possible to some extent, by growing grass (and subsequently bushes and trees according to feasible preferences) with a well-planned R&D effort, e.g. use of organic manure in place of sweet earth and inorganic fertilizers, introduction of legumes for continued supply of nitrogen, etc.

Incidentally, the Ministry of Environment & Forests has laid down regulations which prohibit abandonment of mining activity without implementation of environmental safety measures. Are tailings from mining projects exempted from these regulations?

1. Chenik, D., *J. S. Afr. Inst. Min. Metall.*, 1960, **60**, 525–555.
2. Bradshaw, A. D. and Chadwick, M. J., *The Restoration of Land*, Blackwell Scientific Publ, Oxford, 1981.
3. Chaphekar, S. B. and Bhavanishankar, V., Final Report of work from 1982 to 1986, Hindustan Zinc Ltd, Udaipur, 1987.

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Taxonomy, palaeobotany and biodiversity

The importance of taxonomic and systematic studies in relation to biodiversity is rightly being emphasized in *Current Science*[1–4]. I wish to point out that taxonomy and systematic studies of plant fossils are also being neglected due to an overemphasis on geologic interpretations. In strict sense, palaeobotany is a fundamental science related with the taxonomic study of plant fossils and it reveals the floristic history of the earth at different time scales. Such studies aid in determining the origin, evolution, diversification and establishment of various plant groups in the geologic past. This provides a perspective on the present-day plant communities. The investigation of plant fossils from sedimentary basins of India has helped to identify a new plant group, Pentoxylae, which is unique in having its own systematic position.

The elements of Glossopteris flora available in different Lower Gondwana formations have assisted in recognizing the coal-forming vegetation. However, the exact affinity of Glossopterid group of plants is still uncertain, because of different types of leaves and fructifications; the non-availability of attached specimens of leaf, fructification and stem make the problem much more serious. The taxonomic position of Glossopterid remains uncertain and its relationship has often been ascribed to Cordaitales, Ginkgoales and sometimes with Cycadales[5–7]. Interestingly, the comparative morphological features of leaves and fructifications have led many workers to postulate the origin of angiosperms from Glossopterid group of plants[8,9]. The occurrence of columellate exine structures in pollen of Late Permian sequence further indicates the presence of angiospermic character in Gondwana plant fossils[10]. Such unsolved problems demonstrate that the taxonomy and systematic studies of plant fossils are vital to decipher the affinity of plants.

The study of plant fossils of Mesozoic and Tertiary sediments has provided us data for interpreting the floral history of different groups of gymnosperms and angiosperms. The discovery of primitive angiospermic remains from Rajmahal Hills indicates the earliest history of angiosperms in Early Cretaceous Period of India[11,12]. The palaeobotanical investigations of Tertiary sediments furnish knowledge about the origin, evolution and expansion of modern flora in different parts of India. The earliest discovery of mango-like leaves in north-east region, suggests the possible origin of mango in the Indian subcontinent[13].

The history of plant biodiversity in terms of extant flora can be inferred from the systematic and taxonomic studies of plant fossils of the Tertiary and Quaternary sediments. The informa-

tion may be utilized in understanding the original nature of plant biodiversity, which must have been disturbed due to catastrophic or anthropogenic events. The available records of mangrove flora of coastal regions in Late Quaternary sediments signify the presence of well-organized mangrove plant communities during the period 10,000–5000 years before present[14]. Ironically, today the vastness and richness of mangrove flora is at the receiving end, mainly due to human interference. The fossil history of tropical rain forests of Kerala, Assam and Meghalaya regions yields information about the endemic and exotic nature of plant biodiversity. It has been argued that during the Tertiary Period plant diversity acquired a new dimension due to introduction of new plants from south-east regions, the presence of dipterocarps and legumes in Indian flora has been attributed to this hypothesis[15]. Later, origin of Himalaya changed the biodiversity scenario of India, which is well documented in the palaeobotanical investigations of Rajasthan and Hiamalayan regions[16–18].

The development of biodiversity in terms of animal interaction is also recorded in the fossil flora in the form of insect activities, showing insect-eaten leaves, gall and mining activities[19]. The evidence suggests the antiquity of animal–plant interactions in the geologic past, and hence the nature and complexity of biodiversity.

Is it possible to rejuvenate the plant biodiversity on a site with the introduction of plant elements known from that region from the palaeobotanical study? Can the knowledge of fossil flora of tropical rainforest of the Western Ghats and of the north-east, help in restoring the original nature of plant communities? Why was the rate of speciation high in certain areas and low in others? Why did certain forms continue to the present, while others were lost? Such are the questions that need to be answered.

Without going into other details of plant fossil study, I would like to emphasize that the taxonomic and systematic studies are the foremost components of palaeobotanical researchers. It is awkward and embarrassing, when a 'modern' plant scientist or a geologist asks, 'What is the fun in studying taxonomy of plant fossils?' There are many areas in India from where we have yet to discover and describe plant fossils, in order to complete the vegetational history of the country. The palaeobotanical knowledge of lower groups of plants, e.g. Bryophytes, Psilophytes, Lycophytes, Pteridophytes and Pteridosperms is very meagre in Indian flora. The Pteridosperms and Cordaitales which dominated the flora of the Northern Hemisphere during Late Palaeozoic are practically unknown in the Indian fossil flora. We have yet to understand the morphological and taxonomical features of cycads, conifers and ginkgo in terms of their fertile structures. Unfortunately, the palaeobotanical researches are not being taken up as enthusiastically as they should have been; the centers which were established through the efforts of Birbal Sahni are on the verge of closure. The syndrome is related to the same phenomenon under which the basic science of taxonomy and systematic researches of biology are suffering.

At this juncture as a concerned palaeobotanist, I would like to express my view that systematic and taxonomic study of plant fossils be taken up vigorously and a good data bank be developed, to know the geological history of plants in the Indian context and such researches preferably be integrated under the umbrella of National Consortium and National Agenda for Systematic Biology Research[1].

1. Pushpangadan, P. and Narayanan, N. K., *Curr. Sci.*, 2001, **80**, 631–638.
2. Ananthakrishnan, T. N., *ibid*, 913.
3. Sundaresan, V., Kathiravan, K., Seshadri, S. and Ignacimuthu, S., *ibid*, 912.
4. Manilal, K. S., *Curr. Sci.*, 2001, **81**, 135–136
5. Schopf, J., *Rev. Palaeobot. Palynol.*, 1976, **21**, 26–61.
6. Pant, D. D., *Palaeobotanist*, 2000, **48**, 111–124.
7. Leary, R., Proc. XII Int. Cong. Carbonif. Perm. Geol. Strat., 1993, vol. 2, pp. 107–116.
8. Melvil, R., *Nature*, 1960, **188**, 14–18.
9. Retallack, G. and Dilcher, D. L., *Palaeobiology*, 1981, **7**, 54–67.
10. Tripathi, A., *Geophytology*, 1998, **27**, 7–15.
11. Sharma, B. D., *Phytomorphology*, 1997, **97**, 305–310.
12. Banerji, J., *Cret. Res.*, 2000, **21**, 781–784.
13. Mehrotra, R. C., Dilcher, D. L. and Awasthi, N., *Phytomorphology*, 1998, **48**, 91–100.
14. Gupta, H. P. and Khandelwal, A., *Palaeobotanist*, 1990, **38**, 379, 393.
15. Lakhanpal, R. N., Symp. Origin and Phytogeography, Angiosperms, B.S.I.P., Lucknow, Spec. Publ., 1974, pp. 30–39.
16. Singh, G., Joshi, R. D., Chopra, S. K. and Singh, A. B., *Philos. Trans. R. Soc. London, Biol. Sci.*, 1974, **3267**, 467–501.
17. Puri, G. S., *J. Indian Bot. Soc.*, 1947, **22**, 125–184.
18. Chauhan, M. S., Mazari, B. K. and Rajagopalan, G., *Curr. Sci.*, 2000, **79**, 373–377.
19. Srivastava, A. K., *Palaeobotanist*, 1988, **36**, 138–142.

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