fied products, (e.g. soybean), pressures on land and water resources, and preservation of genetic resources. He stressed the need for increased productivity through science and technology inputs, optimum resource management, education and training of farmers to make them aware of new technologies, regional planning for agriculture, and development of some of the remote areas like the NE region.

In conclusion, it was felt that agricultural diversification within food grains (millets, legumes beside cereals) and between food grains, and horticulture (fruits and vegetables) and livestock products is essential for both national and household food and nutrition security. If planned properly it can benefit the poor both nutritionally and economically.

Mahtab S. Bamji lives at Flat 211, Dattasai Apartments, Musirabad, Hyderabad 500 020, India.

An overview of heavy metals: Impact and remediation*

Heavy metals are considered as major environmental pollutants and are regarded to be cytotoxic, mutagenic and carcinogenic. Prominent sources contributing to contamination of soil are: geogenic, mining and smelting, disposal of municipal industrial wastes, use of fertilizers, pesticides and automobiles. Natural contamination of soil and groundwater with arsenic, selenium and fluoride in many parts of the world, particularly in the Australasia–Pacific region, is a cause of great concern to human health. With this in mind, a conference on contaminants in soil environment in this region was held. The key points that emerged during scientific deliberations are highlighted here. R. S. Paroda (Department of Agricultural Research and Education, and ICAR) in his inaugural address stressed that in the realm of sustainable agricultural development soil health is very important to achieve future food security targets. Saon Banerjee suggested that environmental monitoring of radio nuclide contamination is highly essential as more and more nuclear power plants are expected to be installed for generation of power and in the industry in the future. C. Mahanta studied the distribution and fractionation of Cu, Pb, Zn, Mn, Fe, Ni and Cr along the 700-km stretch of the Brahmaputra river falling within India. Shashi Mathur developed a simple macroscopic root uptake model that simulates both the water and cadmium uptake by plant roots contaminated with sewage sludge. Jeevan Rao concluded that indiscriminate and over use of garbage as manure in Hyderabad for a long time resulted in pollution of natural resources like soil and water and plant growth was also affected due to the build-up of soluble salts, sodium and heavy metals. G. R. M. Reddy reported higher contents of heavy metals, viz. Pb, Cd, Ni, Cr and Co in sewage-irrigated soils of Hyderabad. S. K. Singh predicted the danger of heavy metals build-up in Sikandarabad soils irrigated with mixed industrial effluents. T. Srinath reported that heavy metal contamination (mg/kg) in the sludge of tannery effluent treatment plant was of the order of Cr (37,797) > Fe (2574) > Ni (1287) > Mn (110.6) > Cu (90.4) > Pb (79.8) > Zn (15.5) > Cd (4.6). He also cautioned against the use of tannery sludges as manure in agriculture. O. P. Bansal reported that concentrations of Cr and Cd in groundwater of Aligarh district, Uttar Pradesh were at the threshold level and further accumulation may cause toxicity. V. Bhardwaj reported that the exhaust from the vehicular transport has contaminated the road-side vegetation and soils of Nainital Tarai area with lead. The problem of lead contamination was aggravated by traffic intensity, wind direction and roughness of the leaf surface. K. M. Nair reported that Vrishabhavati river water, the primary source of land pollution in Bangalore, contained Cu 138, Zn 261, Pb 100, Ni 54 and Cr 34 μg/l and plants grown in such soils absorb enough metal to render their edible tissues unfit for animal/human consumption. R. N. Sharma developed a complete early warning system for the detection of copper, mercury, cadmium, lead, chromium, cobalt and aluminium by using biomonitors such as *Poecilia reticulata* (guppy fish), *Ades aegypti* (mosquito), *Musca domestica* (housefly), *Chironomous* sp. and *Mesocyclops leuckrati*. K. Ramasamy reported that tanneries in Tamil Nadu are responsible for elevated levels of Cr, Na and other salts in well waters of Vellore district. Ravi Naidu (Australia) reported higher levels of Cr (800–40,000 mg/kg) in tannery sludges in South India. S. Sakthivel and S. Mahimairaja reported that irrigation with treated tannery effluents had a significant impact on tree growth and marketable flower yield of flower crops. K. Shanthi reported the concentrations of Cu, Zn, Ni, Pb, Cd, Cr, Fe and Mn in sediments of six wet lands of Coimbatore. Mahimairaja assessed the status and distribution of Cr in tannery waste contaminated soils of Vellore district, Tamil Nadu, where > 70% of the tannery industries are located. Total chromium and Cr (VI) in these soils ranged from 154.5 to 568 and from 48 to 467 μg/l, respectively. Narwal cautioned that continuous use of sewage crops may affect the animal/human health adversely by causing accumulation of heavy metals in the soil. M. Bhaskar reported that one-time addition of flyash did not cause heavy metal toxicity that would affect soil health and crop production. U. N. Joshi reported that activity of enzymes related to carbon and nitrogen metabolism increased in 1 ppm Cr(VI) treated plants and then decreased at higher concentrations of Cr(VI), resulting in poor and stunted plant growth at higher Cr(VI) concentrations. In alluvial soils of Punjab the total content of heavy metals (Zn, Cu, Mn and Mo) was by and large within and those of Co and Cr were more than that of the minimum permissible limit (P. N. Takkar). K. S. Dhillon

*Report on the 2nd International Conference on Contaminants in Soil Environment in the Australasia–Pacific Region, held in New Delhi during 12–17 December 1999.

reported that selenium concentration in foodstuffs varied from 5–66 mg/kg dry matter. Selenium toxicity in humans is characterized by loss of hair, nail changes and nervous system abnormalities. D. R. Sharma discussed about the outbreak of lead poisoning and its treatment in cross-bred dairy cattle. Vikas Chaudhary reported that electroplating industries are mainly responsible for chromium contamination in groundwater of Ludhiana in Punjab and it ranged from 10 to 3320 µg/l. B. D. Kansal investigated the extent of contamination of alluvial soils of Punjab with Cd. S. S. Randhawa inferred that prolonged exposure of dairy animals to toxic levels of fluoride (> 1 mg/l) in drinking water resulted in anaemia, hepatic, kidney and bone disorders associated with significant alteration in plasma mineral status. D. Chakraborti reported that more than 100 million people are at risk from groundwater arsenic contamination in Bangladesh and West Bengal. Leachates from mine waste piles and from dumps of floatation waste produce during the refining process and disseminated arsenopyrites in shallow alluvium are the three potential sources of arsenic contamination of groundwater in Thailand (W. Chatupote, Thailand). S. K. Sanyal reported that soil contamination with arsenic may have toxic effect on vegetation and the animals feeding on the latter accumulate arsenic in the body, thereby aggravating the problem of arseniosis (S. M. Imamul Huq, Bangladesh). Prosun Bhattacharya (Sweden) supported the hypothesis that arsenic in groundwater is released due to desorption as well as reductive dissolution of ferric hydroxides present within the classic aquifer sediments. However, Chakraborti concluded that a single mechanism need not be responsible for arsenic release from aquifer sediments in West Bengal and Bangladesh and that pyrite oxidation, iron oxyhydroxide reduction hypothesis and microbial activities deserve further consideration. S. I. Kwon (Korea) studied the effect of long-term application of municipal sewage sludge, industrial sewage, leather processing sludge, alcohol fermentation sludge and pig manure compost on the distribution and availability of Cr, Mn and Zn, and suggested that soil pH affected plant uptake of heavy metals. Balram Singh (Norway) reported that leaves of coffee plants had highly toxic concentration of Cu (752–867 mg/g). Jack C. Ng (Australia) highlighted the relevance of arsenic speciation and showed that arsenite (As^{3+}) components were 0.32 to 56 per cent in the soil and 44.8 per cent in rock composite samples of a residential suburb of Watson in Canberra. He further reported that urinary arsenic levels were below the NHMRC guideline value of 150 µg As/g creatinine. Ravi Naidu presented an overview of arsenic contamination at the farmer cattle tick dip contaminated sites and the leachability and potential bioavailability of arsenic in contaminated soils of Australia.

Remediation of metal contaminants is an emerging field in the broad area of environmental bio-geo-technology. Prospective strategies for the remediation of heavy metal contaminated soils were also discussed by several researchers which are presented here.

Ravi Naidu suggested that allophane-bearing and halloysite-bearing clays are economical barrier materials than the expensive bentonite clays for the removal of Cd from the waste disposal sites. Surya Pandey (New Zealand) reported that *Sphagnum moss*, crushed limestone, waste wood pulp, flyash and waste wool felt could be used as substrates to remove heavy metals (Cu, Pb and Zn) from artificial road run-off. Zueng-Sang Chen (Taiwan) reported that soil amended with calcium carbonate could significantly reduce the uptake of Cd in wheat grain. M. Maheswari reported the reduction in the content of heavy metals after 60 days of composting in the vermicompost prepared with *Azotobacter*, *Azospirillum* and phosphorus solubilizers. C. Paulraj indicated that sewage sludge composted with poultry manure at 1 : 3 ratio minimized the heavy metals enrichment and their availability in soil. M. N. V. Prasad and R. R. Brooks (New Zealand) suggested the use of heavy metal hyperaccumulators for remediation of heavy metals. *Brassica juncea* (cv. Vardan) has a higher potential for removing Cd from moderately contaminated soil (Kuldeep). Similarly, *Eichhornia crassipes* plants may also be used as phytoextractor of Cr from tannery effluents (J. Balamurugan). The arbuscular mycorrhizal fungi have the potential to play an important role in soil remediation by enhancing growth and biomass of the hyper accumulator plants on contaminated sites (A. G. Khan, Australia). M. T. Liao (New Zealand) reported that *Berkheya coddi* could be used for phytoremediation of multielements. Balram Singh (Norway) and D. Augustine Selvaseelan discussed the use of lime, farmyard manure, tree leaves, zeolites or iron oxides/hydroxides, alum, superphosphate and flyash for reduction of Cu, Ni, Cd, Zn and Pb in the growth medium. Application of 4 per cent cow manure reduced the concentration of Cd, Ni and Zn in rice plants under both flooded and non-flooded conditions (Md. Abdul Kashem, Norway). R. H. Iyer demonstrated the feasibility of using supported liquid membranes (SLMS) for the removal of many toxic elements (Ni, Co and Hg) from aqueous waste solutions. K. M. S. Sumathi reported that sawdust and coirpith could effectively be utilized for removal of Cr from the tannery effluents. K. Ramasamy indicated that some suitable earthworm species were able to solve the problem of tannery sludge disposal. Padma Vasudevan reported the efficiency of bacteria for cadmium removal from waste waters through biosorption on biomass derived from yeast. T. Chakrabarti reported that certain binary metal combinations such as Cr and Cd, Cu and Ni, and Pb and Cd when added at the subtoxic level could prevent partially or wholly the adverse effects of sludge application.

Besides the aforesaid remedial techniques, environmental education and awareness programmes should be implemented for the masses because 'unless the environment is healthy the individual cannot be healthy'.

U. N. Joshi and Y. P. Luthra, Chemical Laboratory, Department of Plant Breeding, CSS Haryana Agricultural University, Hisar 125 004, India.