ENVIRONEWS

INTERNATIONAL SOCIETY OF ENVIRONMENTAL BOTANISTS

Newsletter

LUCKNOW (INDIA) VOL 20 No 1 January, 2014

IN THIS ISSUE

President ISEB's New Year Message

Environews is a quarterly newsletter of the International Society of Environmental Botanists (ISEB), which is based at CSIR-National Botanical Research Institute in Lucknow. The current issue is the seventy-seventh issue of this news magazine which has a worldwide circulation. While more than 400 printed copies of this newsletter are circulated to the members of ISEB in India, over 2000 members and non-members in different parts of the world regularly receive its electronic version. Though Environews is basically a popular science magazine catering to non-specialists, it does publish hard core scientific articles of great academic value. Some of these articles are greatly appreciated by researchers and academicians, who often cite them in their research papers, published in international scientific journals.

ISEB, which was founded in 1994 with 28 members, now enjoys a membership of well over 400, which is growing steadily. Apart from organizing regular student-centric outreach programmes, ISEB has successfully organized four international conferences on Plants & Environmental Pollution for researchers in environment and plant sciences at CSIR-NBRI in 1995, 2002, 2005 and 2010. The next Conference (ICPEP-5), is scheduled to be organized during December 3–6, 2014. We have already started pre-registration for this Conference and, as of today, we have pre-registered over 775 delegates, including nearly 115 delegates from 47 foreign countries. This is an all time record which bears enough testimony to the increasing global reach and popularity of these conferences. I invite you to participate in this Conference and interact with a large number of scientists from different parts of the world. This Conference will also provide you an opportunity to visit state-of-the-art laboratories of CSIR-NBRI located on its vast and picturesque campus and interact with scientists of this Institute, which is one of the leading plant science institutes of Asia.

On behalf of ISEB, CSIR-NBRI and on my own behalf, I extend my warmest greetings and best wishes to the readers of Environews, members of ISEB and delegates of ICPEP-5 for the New Year (2014).

Chandra Shekhar Nautiyal
President ISEB &
Director, CSIR-NBRI & CSIR-CIMAP,
CSIR- National Botanical Research Institute, Lucknow, India

Happy New Year 2014

President and Members of the Executive of International Society of Environmental Botanists Wish a Very Happy, Fruitful and Prosperous New Year to all Members of ISEB and readers of ENVIRONEWS

With this issue,
Environews enters the twentieth year of its publication

LETTERS

Congratulations for a commendable start. The registration for the upcoming International conference is also encouraging. I am sure it will not take ISEB long to make its meaningful visibility in not only India, but the world over.

Prof. R.K. Kohli, Ph.D.
FNA, FASc, FNASc, FNAAS, FNESA, FBS
Certified Senior Ecologist, ESA, USA
JC Bose National Fellow, Vice-chancellor
DAV University, Jalandhar, **India**
< rkkohli45@yahoo.com, rkkohli45@gmail.com >

I wish to thank all my well wishers for their good wishes and prayers when I was in hospital. Their goodwill gave me the courage I needed as it was a very traumatic and difficult period for me

I am now home and recovering each day. I need to build more strength, particularly, in my arms as both were very badly damaged. But doctors assure me that this is a matter of time. I hope to be back at work soon. But what this accident has brought home to me is firstly, there is enormous `goodness' in our country something we often forget. Strangers (I still have not been able to find them in spite of my efforts) helped me that early morning when I was lying bleeding on the road and they took me to the AIIMS Trauma Centre where I got excellent treatment. I also was really touched by the dedication and commitment of the doctors at the Trauma Centre.

Secondly I learnt that our work is important. During the time I was in the hospital my colleagues kept bringing to me a number of calls, SMS messages, cards and flowers that were being sent for me and I have to say that all that meant so much to me. These messages told me that we were making a difference. They give me the strength and the belief that we must carry on.

Thirdly, of course, my accident reinforced my anger against the way we are planning our cities – what we do not even have the right to walk or cycle. Clearly this must change. I wrote an article on this surgery last week using my one finger to type. We will soon discuss how to strengthen our campaign for these rights. Your support meant a lot to me in this very difficult time.

Sunita Narain
Director-General of CSE and publisher of *Down To Earth* &
Environmentalist, New Deilhi, **India**
sunita@cseindia.org

Environews of October 2013, brought out three outstanding, highly thought provoking reports on the Utrakhand disaster. Save Himalayas by C. S. Nautiyal; report on the seminar on Himalayan Devastation and Eco-balancing at Lucknow University by S. C. Sharma; and Lessons of Ecology: Not yet Learnt by A. K. Gupta, S. S. Nair and Mohammad Yunus all point to ecologically unsustainable development in the Himalayas. Increase in human population, both residents as well as annual influx of tourists and pilgrims, and consequent anthropogenic pressure are the main cause of ecological imbalance as brought out by Nautiyal at the Seminar. Gupta, Nair and Yunus have gone a step ahead to attribute the disaster to "deliberate ignorance" of carrying capacity. It is further stated that the concept of carrying capacity based planning was piloted for Doon valley region in 1995, but seldom brought to planning and policy. Consequences of ignoring the carrying capacity of man-made machines, transport vehicles, bridges and elevators are well known. Bridges collapse, boats sink, people fall to their death from trains, as often happens from over-crowded local trains in Mumbai, and elevators do not move. Though often not appreciated or deliberately ignored, the same hold true for nature and for the Himalayas. The concept of carrying capacity is also used for places of tourist interest abroad to restrict overcrowding. I have been advocating and seeking support for carrying capacity based planning for food production in the country (NAAS, Policy Paper 51; Current Science, special section on carrying capacity of Indian agriculture, 102; 867-898, March 25, 2012.

My childhood memories of the Himalayas go back to 1942 when at the age of six there was an opportunity to spend the summer at Nainital. Since then, I have been periodically visiting the three popular hill stations in the Himalayas – Nainital, Mussoorie and Shimla. The consequences of population increase are visible all over, and as a layman I find the growth unsustainable and beyond the carrying capacity. The future of Himalayas should be a matter of concern to all Indians and members of ISEB. Scientists from CSIR-NBRI, with their vast collective knowledge, should join hands with the locals to aim for more sustainable growth in the Himalayas. At times, this may involve de-growth, economic contraction and considerable sacrifices in ostentatious social, family and individual life styles.

Dr. C.R. Bhatia
Former Secretary, Department of Biotechnology, Govt. of
India, Navi Mumbai
crbhatia.bhatia@gmail.com

WELCOME NEW LIFE MEMBERS

Dr. N.R. Suman, Assistant Professor, Botany Department, Government .P.G. College, Damoh (M.P.), India.
drnrsuman@gmail.com

Dr. Komal Arora, Head of Botany Department, DAV College, Jalandhar, Punjab, India.
drkomalswami@yahoo.com

Dr. Vaneet Jishtu, Scientist, Himalayan Forest Research Institute Shimla, India.
jishtu@yahoo.com; jishtu@hotmail.com

Dr. Uppu Anitha Devi, Lecturer in Botany Department, Government Degree & P.G. College for Women, Karimnagar, A.P., India.
nithasreedhar86@gmail.com

Dr. Sanjay Kumar, Chief Scientist, CSIR-Institute of Himalayan Bioresources Technology, Palampur, H.P, India.
sanjaykumar@ihbt.res.in

NEWS FLASH

Prof. C.K. Varshney Professor Emeritus School of Environmental Sciences, Jawaharlal Nehru University, New Delhi and, an Advisor of ISEB has been given "VASVIK AWARD" in Environmental Sciences and Technology. The award was given by Dr R. A. Mashelkar, former Director General CSIR at a formal ceremony held on 14th of December 2013 in Mumbai Prof Varshney is also founder Member of ISEB.

Prof. P. K. Seth, an internationally renowned neuro-biologist, toxicologist and biotechnologist of the country, and CEO of Biotechnology Park, Lucknow, has been nominated as an Advisor of International Society of Environmental Botanists by the Executive Committee of ISEB. Dr. Seth is a former Director of CSIR-Indian Institute of Toxicology Research, Lucknow and Adjunct Professor, Toxicology, Jamia Hamdard (Hamdard University New Delhi). He is a Life member of ISEB. Dr. Seth was also elected a member of ISEB's first Executive Committee at the time of its founding. Biotech Park is also a Patron member of ISEB.

Best Research Paper Award of the CSIR-National Botanical Research Institute, Lucknow was presented to Drs. Sanjay Dwivedi, Aradhana Mishra, Preeti Tripathi, Richa Dave, Amit Kumar, Sudhakar Srivsastava, Devashish Chakrabarty, P.K. Trivedi, Bijan Adhikari, G.J. Norton, R.D. Tripathi and C.S. Nautiyal for securing the highest impact factor for the paper entitled "Arsenic affects essential and non-essential amino acids differentially in rice grains: Inadequacy of amino acids in rice based diet" published in *Environment International* Vol. 46, pp. 16-22, 2012 which is the **Best in the Institute.** The awardees include Dr. C.S. Nautiyal, President ISEB, Dr. R.D. Tripathi, Additional Secretary, ISEB and Drs. P.K. Trivedi, D. Chakrabarty, S. Srivastava, S. Dwivedi, R. Dave and Ms. Preeti Tripathi who are Life members of International Society of Environmental Botanists (ISEB).

The Annual Function of the Lucknow University Botany Department Alumni Association (LUBDAA) was organised on 13th December 2013 under the guidance of Prof. Y.K. Sharma, Head, Botany Department and an Executive Councillor of ISEB at Lucknow University. On this occasion some senior distinguished alumni were felicitated by Prof. S. B. Nimse, Vice- Chancellor of the University with the citations and mementoes. Those honoured by LUBDAA included Dr. C. S. Nautiyal, President of ISEB and Director CSIR-NBRI; Dr. S. C. Sharma, Vice President, ISEB and Dr. K. J. Ahmad Secretary, ISEB.

Dr. Tariq Husain, Principal Scientist at CSIR-National Botanical Research Institute, Lucknow and an Executive Councillor of ISEB delivered the Prof. G. Panigrahi Memorial Lecture 2013 entitled "Plant Diversity in Indian Himalayan Region: Inventorization, Bioprospection and Conservation" during the 36th All India Conference of Indian Botanical Society held at Gorakhpur from 18 – 20 October, 2013.

Dr. Priyanka Agnihotri, Scientist at CSIR-National Botanical Research Institute, Lucknow and a Life member of ISEB has been awarded Women Scientist Medal of Indian Botanical Society for the Year 2013.

Dr. P.C. Abhilash, Assistant Professor, Institute of Environmental & Sustainable Development, Banaras Hindu University and; a Life Member of ISEB has been selected as an Associate of the National Academy of Agriculture Science w.e.f. 1st January 2014.

Mr. Om Narain Bansal, former Mayor of Lucknow and Patron member of International Society of Environmental Botanists, passed away on November 24, 2013 in Lucknow. He was 83.

Lichens as Sentinels of Atmospheric Polycyclic Aromatic Hydrocarbons (PAHs) in India

Vertika Shukla and D.K. Upreti
Lichenology Laboratory, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow 226 001, **India**
<upretidk@rediffmail.com>

Polycyclic aromatic hydrocarbons (PAHs) are a group of organic compounds with two or more fused aromatic rings. PAHs are widespread environmental contaminants resulting from incomplete combustion of organic materials. Anthropogenic activities such as fossil fuel-burning, motor vehicle, waste incinerator and oil refining are the major sources of PAHs in environment (Table 1). PAHs are hydrophobic having a relatively low solubility in water, but are highly lipophilic. PAHs can undergo photodecomposition when exposed to ultraviolet light from solar radiation. In the atmosphere, PAHs may react with pollutants such as ozone, nitrogen oxides and sulfur dioxide, yielding secondary compounds like diones, nitro- and dinitro- PAHs, and sulfonic acids, respectively.

Among different derivatives, nitrated polycyclic aromatic hydrocarbons (N-PAHs) are an important category of derivatives of PAHs. N-PAHs have been recognized as direct-acting mutagens and carcinogens to mammalian systems. Thus the N-PAHs are considered to have far greater toxicity than non substituted PAHs. Nitro-PAHs are formed mainly from incomplete combustion processes or by the reaction of PAH with atmospheric oxidants, such as dinitrogen pentoxide, nitrogen trioxide, and oxygen radicals in the presence of nitrogen oxides. Nitro-PAHs occur as a mixture with parent PAHs in the vapor phase or adsorbed onto particulate matter in the atmosphere. Two-ring N-PAHs, such as nitro-naphthalene, are the dominant N-PAHs in the vapor phase. However, N-PAHs, which include nitro derivatives of pyrene, fluoranthene, anthracene, chrysene, and others, tend to condense on particle surfaces because of their low vapor pressure. Atmospheric lifetimes of N-PAHs are affected by photolysis and gas-phase reactions with hydroxyl and nitrate radicals and with ozone under atmospheric conditions.

In urban areas, N-PAH pollution is predominantly caused by diesel engine, vehicle traffic and residential heating. Indoor human exposure to nitro-PAHs is from kerosene heating and use of cooking oil. Effects of N-PAHs on human health have been estimated based on the data of carcinogenic effects for 28 N-PAHs.

PAHs have received increased attention in recent years in air pollution studies because some of these compounds are highly carcinogenic or mutagenic. The Stockholm Convention on Persistent Organic Pollutants (POPs) which was adopted in 2001 and revised in 2009 was called in response to the urgent need for global action to protect human health and the environment from chemicals that are highly toxic, persistent, bio accumulate and move long distance in the environment. The Convention seeks the elimination or restriction of production and use of all unintentionally produced PAHs. In absence of strict EIA norm developing countries are more prone towards emission and direct environmental exposure to these hazardous compounds. Thus the exposure assessments of PAHs in the developing world are important.

Health risk associated with PAHs

Air with high concentrations of PAHs causes many adverse effects on different types of organisms, including plants, birds, and mammals. Some studies reported that there is a significant positive correlation between mortality by lung cancer in humans and exposure to PAHs from exhaust from coke ovens, roofing-tar, and cigarette smoke. Some PAHs have been demonstrated to be carcinogenic in humans and experimental animals, and they are classified as carcinogenic materials by many environmental protection agencies as "priority pollutants". Eight PAHs (Car-PAHs) typically considered as possible carcinogens are: benzo(a)anthracene, chrysene, benzo(b) fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene (B(a)P), dibenzo(a,h)anthracene,

Table 1: Predominant PAHs as markers of its anthropogenic source

S. No.	Sources	Fingerprint PAHs
1	Coal combustion	Phenanthrene, fluoranthene and pyrene
2	Coke production	Anthracene, Phenanthrene and benzo(a)pyrene
7	Diesel powered vehicles	Fluoranthene and pyrene with higher ratios of benzo(b)Fluoranthene and benzo(k)fluoranthene
3	Incineration	Pyrene, Phenanthrene and fluoranthene
5	Industrial – oil burning	Fluoranthene pyrene and chrysene
6	Petrol powered vehicles	Benzo(ghi)pyrelene, indeno (123-cd)pyrene and coronene
4	Wood combustion	Benzo(a)pyrene and fluoranthene

indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene. In particular, benzo(a)pyrene has been identified as being highly carcinogenic. Low molecular weight PAHs, except naphthalene, usually are associated with relatively lower toxicity (cancer risk) than High molecular weight PAHs with 5 or 6 aromatic rings. Many toxicity studies reported that benzo[a]pyrene (BaP) has the highest carcinogenic potency with long-term persistency in the environment. Significant increase in all lung tumors and a dose-dependent increase in malignant lung tumors for mice exposed to PAH-enriched exhausts containing 0.05 or 0.09 mg/m3 BaP has been observed. BaP is often used as an indicator of human exposure to PAHs, and the toxicity of other PAHs is converted into toxicity equivalency factors (TEFs) to BaP to evaluate their relative toxicities. Methods using TEFs and the BaP as a surrogate are more or less similar to each other, except for not requiring expensive monitoring.

Health Risk Estimation

Toxicity equivalency factors (TEFs) evaluation is the most popular method used to identify the toxicity of PAHs. TEFs of individual PAHs have been reported by many researchers. Toxicity equivalency concentrations (TEQs) are calculated as the product of summing up the values obtained by TEF values and concentrations of PAHs, as follows: $TEQ = \Sigma (C_i \times TEF_i)$

Where, TEQ: toxic equivalent concentration; C_i: concentration of PAH_i.

TEFs has been successfully employed in assessing occupational and environmental health risks associated with exposure to airborne mixtures of PAHs. Information of the ratio between airborne concentrations of BaP equivalents to the concentrations of BaP alone, can indicate the variation of risk for the different environments. 1.73% of the cancer sufferers of Beijing inhabitants in 2007 were found to be related to inhalation of PAHs in ambient air. There is an increasing trend of the cancer risk of residents by inhalation of ambient air containing hazardous air pollutants (HAPs), such as PAHs.

The BaP is the highest carcinogenic contributor, followed by DahA, Ind and BbF. However, DahA was suggested as a new surrogate compound to measure the toxicity of particle phase-PAHs because its toxicity is almost equal to that of BaP. While estimating the toxicity of PAHs in road dust of Ulsan, Korea, significant correlation coefficient was found between TEQ and total PAH concentrations.

Another index for calculation of PAHs associated health risk is BaPE index. B(a)P, the classical chemical carcinogen, is considered to be the useful indicator for cancer risk assessment. According to World Health Organization (WHO), B(a)P is considered to be reliable index for assessment of total PAHs carcinogenicity. Since B(a)P is easily oxidized and photodegraded therefore PAHs carcinogenic character could be underestimated. For better quantification of carcinogenicity related to whole PAH factor, BaP-equivalent potency (BaPE) index after Yassaa et al., is calculated. High BaPE index indicates high cancer risk is associated with high vehicular activity. In a study carried out in Mahabaleshwar (India) it was observed that BaPE was higher at sites with heavy traffic load. Thus urban population appears to be exposed to significantly higher cancer risk. Distribution and uptake by plants PAHs are semi volatile organic compounds (SOCs) in nature that are found in air, soil, vegetation, water and ice, i.e., multi-compartmental substances. PAHs are mostly distributed in the source regions but reach the Arctic and the Antarctic. The gas/particle partitioning in air influences the atmospheric cycling and the total environmental fate (compartmental distributions). Re-volatilization is significant phenomenon for semi volatile PAHs for its long range transport (LRT) potential.

Partition between the vapor and particulate phases, affects the deposition, degradation, transportation, and subsequent fate of these environmentally significant constituents. Distribution between the vapor and particulate phases can also be important to plant exposure to these potentially harmful chemicals.

The amount of uptake of PAHs by plants varies significantly and depends on many factors, including plant species, initial soil concentrations and microbial population. Several studies have demonstrated that vegetables grown in soil contaminated with PAHs may uptake PAHs. Laboratory experiments of PAH uptake in plants grown in spiked soil, or directly in contaminated water, also show that uptake occurs. Several mechanisms may be responsible for the transfer of organic contaminants from soil to plant tissue, including uptake in the transpiration stream, volatilization and subsequent re-deposition on leaves, and sorption from direct contact with soil particles. Atmospheric deposition has been identified as a predominant pathway of PAHs uptake in many studies including lichens.

Perspective of lichen biomonitoring of PAHs

As PAHs pose significant potential health and environmental risks at varying spatial scales, ranging from localized to global scales. Thus, there is increasing interest in monitoring the levels and distribution of pollutants. Such monitoring programs implicitly involve sampling ambient air, but this is often hampered by problems associated with sampling air in remote areas. A potentially useful approach is to use biomonitors such as lichens, which concentrate a variety of pollutants in their tissues.

In particular, lichens function as an efficient bioindicator and bioaccumulator organisms, because of several factors, as they are perennial, maintain uniform morphology over time, grow slowly, and are dependent on atmospheric deposition for their mineral nutrition. Lichens have no roots and adsorb water and nutrients directly from the air; consequently, they may co-adsorb/absorb other substances from the atmosphere, including pollutants. Thus, lichen data can be used to identify areas that may require more intensive or quantitative monitoring using devices.

Biomonitoring studies utilizing lichens

Table 2: Total PAHs concentration in various lichen species sampled from different regions of India.

Lichen species	Locality	ΣPAHs (in μg/g)
Acarospora bullata	Mana (Uttarakhand)	30.07
A. praeradiosa	Mana (Uttarakhand)	22.98
Dermatocarpon vellereum	Joshimath (Uttarakhand)	33.72
D. vellereum	Rudraprayag (Uttarakhand)	4.96
Dimelaena oreina	Mana (Uttarakhand)	18
Heterodermia angustiloba	Badrinath (Uttarakhand)	32.98
Lepraria lobificans	Rishikesh (Uttarakhand)	43.1
Phaeophyscia hispidula	Badrinath (Uttarakhand)	7.7
P.hispidula	Dehradun (Uttarakhand)	25.01
P. hispidula	Dehradun (Uttarakhand)	5.3
Phaeophyscia orbicularis	Srinagar (Uttarakhand)	2.653
Pyxine subcinerea	Haridwar (Uttarakhand)	187.3
Remototrchyna awasthii	Mahabaleshwar (Maharashtra)	54.78
Rinodina sophodes	Kanpur city (Uttar Pradesh)	0.49

carried out globally show that lichens can accumulate PAHs of all sizes. Lichens accumulate substances in the gas phase more easily, but can also accumulate compounds bound to particulate matter. The highest concentrations were observed for three-ring and four-ring PAHs molecules, whereas concentrations of five- and six-ring chemicals were the lowest.

In India PAHs accumulation studies (Table 2) with lichens have been recently initiated in the Himalayan region of Uttrakhand. The first baseline data on the distribution and origin of polycyclic aromatic hydrocarbons (PAHs) in Garhwal Himalayan region has been prepared which exhibit the presence of all 16 USEPA PAHs in the region. Significantly higher concentration of phenanthrene, pyrene and acenapthalene indicates road traffic as major source of PAH pollution in the area. The probable mechanism of bioaccumulation may be attributed to the donor-acceptor complex has been reported to be formed between polycyclic aromatic hydrocarbons (carcinogenic and noncarcinogenic), and compounds of biological importance.

Apart from quantification of PAHs, lichen biomonitoring has been successfully employed to distinguish industrial PAHs from urban PAHs, which reveal that 5 and 6 ringed PAHs are predominant in industrial emissions while lower molecular weight PAH are of urban origin (vehicular activity, cooking and coal combustion etc.). Spatial distribution of PAH profile reveals that fluoranthene (4-ringed PAH) has highest spatial continuity, this has been established by modeling studies which has been further affirmed by lichen biomonitoring studies carried out in high altitude Himalayan ecosystem of Uttarakhand.

In India PAHs profile in lichens considerably varies from site to site. Diagnostic molecular ratio has been applied to the biomonitoring data and the results were found to be in conformity with the pollution source, dominant mode of transport. As in Hardwar city, commercial and tourist activity encourages more and more diesel driven vehicles, has been affirmed by diagnostic ratios at industrial and city center, an important holy pilgrimage, having combustion being predominant source.

Growth form of lichens may also play a significant role in the accumulation of PAHs. The crustose and squamulose species growing (thallus is small) on rocks mostly accumulate uniform concentration of low molecular weight 2 and 3 ringed compounds, as these PAHs are prominently in gas phase while foliose lichens are considered better accumulator and indicator profile of PAHs as the larger thallus allows adsorption as well as absorption of particulate bound and gas phased PAHs respectively in the lichen thalli. Ultra structural study of lichen Pyxine subcinerea shows that thallus surface is not uniform but has hexagonal compartments which act as sink for particulate matter to get adsorbed and remain adhered to the thallus surface. Studies carried out till now in India, establishes the utility of member of the Physciaceae family (Pyxine subcinerea and Phaeophyscia hispidula) as an excellent biomonitoring organism in monitoring of PAHs from foot hill to sub-temperate area of the country and may be effectively utilized in the other part of the country with transplant studies.

Conclusion

As PAHs and its derivative pose health risk, therefore for regulation and monitoring, of its emission and dispersal, is required to be carried out regularly and at wider spatial scale. As lichen species absorb airborne contaminants and accumulated them at rates that are generally proportional to pollution load. Therefore lichen biomonitoring data may be well utilized in regulatory management practices. Lichen biomonitoring can supplement the air sampling studies for detection and quantification of PAH pollution especially in remote areas where installation of heavy equipments is not possible. Environmental protection and ensuring healthy environment is an integrated effort which needs to be enforced, implemented and realized for future generations.

Arsenic: a toxicant

Saumya Srivastava and Yogesh Kumar Sharma*
Department of Botany, University of Lucknow, Lucknow, **India**
<yogesh_s26@yahoo.com>

Arsenic, a known carcinogen and a toxic metalloid, is slowly engulfing the entire world under its influence. At present, arsenic (As) has been taken into account as a dangerous environmental pollution and detected as a serious health risk in many countries of the world. Sometimes known as the King of Poisons, arsenic has been known to human kind for thousands of years, being used to harden bronze in the Middle East around 3000 BC, and prized as a dye by the Egyptians, Greeks and Romans. In the fifth century BC, Hippocrates suggested using arsenic compounds as an ulcer treatment, while in the 1st and 2nd centuries AD, the Roman Emperor Nero and Mithridates, King of Poutus, both used arsenic to murder their enemies. The first report of widespread environmental problems with As involved the leaching of the metal from mine tailings in Australia, Canada, Mexico, Thailand, the United Kingdom, and the United States. Later, As-contaminated aquifers were reported in Argentina, Bangladesh, Cambodia, Chile, China, Ghana, Hungary, Inner Mongolia, Mexico, Nepal, New Zealand, Philippines, Taiwan, the United States, and Vietnam. Consumption of water from these naturally contaminated aquifers led to chronic As poisoning in many of these locations, with perhaps the worst situation existing in Bangladesh.

Arsenic is a widely dispersed element in the Earth's crust and exists at an average concentration of approximately 5 mg/kg. Possible routes of human exposure to arsenic are from both natural and anthropogenic sources. In the environment, As can exist as inorganic or organic species. Of the two inorganic forms, the more highly oxidized arsenate (AsV) predominates in aerobic environments, while the more highly reduced arsenite (AsIII) is the predominant form in anaerobic environments, such as flooded rice paddy fields. AsV is an analog of inorganic phosphate (Pi) and is easily transported across the plasmalemma by Pi transporter (PHT) proteins while arsenite and undissociated methylated As species through the nodulin 26-like intrinsic (NIP) aquaporin channels. Arsenate is readily reduced to arsenite in plants, which is detoxified by complexation with thiol-rich peptides such as phytochelatins and/or vacuolar sequestration.

Arsenic occurs as a constituent in more than 200 minerals, although it primarily exists as arsenopyrite and as a constituent in several other sulfide minerals. Man made sources like smelting etc., insecticides, herbicides, dessicants and wood preservatives together with feed additives account for main anthropogenic sources of arsenic. Lastly, fossil fuel combustion also produces quantities of arsenic that may lead to long-term accumulation from the gases emitted to the surrounding areas. All of these factors release arsenic into the environment and can result in its accumulation in soils. Permissible limit of arsenic in agricultural soils is 20 mg/kg soil.

A large number of people are exposed to arsenic chronically throughout the world. Exposure occurs via the oral route (ingestion), inhalation, dermal contact etc. Several studies have indicated that the toxicity of arsenic on humans depends on the exposure dose, frequency, duration, the biological species, age and gender, as well as on individual susceptibilities and genetic and nutritional factors. The first symptoms of chronic long-term exposure to low levels of As result into arsenicosis which includes skin discolorations, chronic indigestion, and stomach cramps. Longer-term effects include skin, lung, kidney, and liver cancer as well as gangrene-like sores. Food and drinking water together account for 99% of the total human intake of As. Arsenic contamination of groundwater is often due to naturally occurring high concentrations of arsenic in deeper levels of groundwater. In the absence of an alternative source, people in acute arsenic problem areas are drinking arsenic-contaminated water without paying much attention to possible consequences and ill effects. Symptoms of arsenicosis are also seen in inhabitants of the contaminated area as brittle nails, deformity in hands and pigmentation. In soil the arsenic concentration from 5.40 to 15.43 ppm is quite toxic especially for sensitive crops (e.g. green beans, lima beans, spinach, cabbages, tomatoes etc.). In this way, not only humans, but plants too are suffering from its toxic effects. The soils of many regions of the world have become contaminated and unfit for cultivation of especially arsenic sensitive crops. Moreover, irrigation with arsenic laden water has exacerbated this problem by further adding arsenic to the soil. The added arsenic gradually accumulates in the soil, and reaches the toxic levels, and it is hazardous to crops in some soils that have been irrigated with highly contaminated water for 10–20 years or more.

Arsenic is non-essential and generally toxic to plants. Roots are usually the first tissue to be exposed to As, where the metalloid inhibits root extension and proliferation. Upon translocation to the shoot, As can severely inhibit plant growth by slowing or arresting expansion and biomass accumulation, as well as compromising plant reproductive capacity through losses in fertility, yield, and fruit production. There is significant evidence that exposure to inorganic arsenic species results in the generation of reactive oxygen species (ROS). At sufficiently

*Professor & Head, Department of Botany, University of Lucknow, Lucknow, India

high concentrations, As interferes with critical metabolic processes, which can lead to death. Most plants possess mechanisms to retain much of their As burden in the root. However, a genotype-dependent proportion of the As is translocated to the shoot and other tissues of the plant.

AsV and AsIII both disturb plant metabolism, but through distinct mechanisms. AsV being a chemical analog of phosphate, disrupts at least some phosphate-dependent aspects of metabolism. It can compete with phosphate during phosphorylation reactions, leading to the formation of AsV adducts that are often unstable and short-lived. Like, the formation and rapid autohydrolysis of AsV-ADP sets in place a futile cycle that uncouples photophosphorylation and oxidative phosphorylation, decreasing the ability of cells to produce ATP and carry out normal metabolism. AsIII is able to enter root cells through nodulin 26-like intrinsic proteins. These proteins belong to the aquaporin family of major intrinsic proteins. In rice roots, the OsNIP2;1/OsLsi1 silicon transporter has been implicated as the major AsIII uptake protein, while AsIII efflux from rice root cells to the xylem is through the OsLsi2 silicon transporter. Other types of proteins may also facilitate the transport AsIII into cells.

Besides other remedial approaches being present like zinc and selenium fertilization, iron plaque formation, mycorrhizal association etc., and modern breeding and genetic engineering methods, phosphate application definitely proves to be one of the important remedial methods because of it being analogus to As, and sharing the same carriers for its uptake.

Salicornia brachiata – a boon to saline soils

G.M.Narasimha Rao

Department of Botany, Andhra University, Visakhapatnam-530003, **India**

<gmnrao_algae@hotmail.com>

Mangroves are evergreen tidal forests between land and sea. While Sunderbans are the second largest mangroves in the world, Godavari mangroves are the second largest mangrove ecosystems in India. In mangrove forests there are three different groups of communities coexisting with each other; those are true mangroves, associated mangroves and halophytes. Halophytes are a group of salt tolerant, drought resistant plants which grow in transitional zone in between terrestrial plants and mangrove plants. Halophytes are used as food, fodder, fertilizer and have several medicinal applications by the local communities since long back. Among these halophytes *Salicornia brachiata* is one of the most important plant materials for various applications in daily life. Plants, popularly known as Sea asparagus are cooked and eaten or pickled. It is also a good fodder for cattle, sheep and goat. Plant material is also used as raw material in paper and board factories. Its seeds yield high quality edible oil which is highly poly-unsaturated and similar to safflower oil. Recent investigations revealed that this halophyte is one of the potential plants for extraction of bio-fuels. *Salicornia brachiata* is a halophyte which occurs along the estuarine habitats of the tropical and temperate water of the Globe. In Andhra Pradesh abundant biomass was reported in the estuarine regions of the Godavari estuary. Department of Science and Technology, Government of India, sponsored a project entitled "Distribution, cultivation and conservation of *Salicornia brachiata*: A potential halophyte for the bio-fuels. Aqua culture in coastal regions of Andhra Pradesh was instrumental for changing the life styles of local communities, but on the other hand there was a problem with intrusion of salt water into the paddy fields. During this period due to wide spread viral diseases in shrimp cultivation some of these aqua cultural units were closed. Besides, there is plenty of saline soil resources which are available along the estuarine habitats of the Andhra Pradesh. Land, which had been unused will be reclaimed allowing for new coastal communities, more jobs and with benefit the environment. *Salicornia brachiata* is able to grow and give good return in saline soils only. Cost of its cultural operations is significant and no technical guidance is needed for its commercial cultivation. With minimum manpower, one can get good results with support of the companies for buying this product. The commercial production of *Salicornia brachiata* with sea water can contribute towards balancing the Earth's carbon dioxide cycle having impact as the 'Green house effect.' During our investigations we have conducted the hydrographical studies, sediment analysis and cultural investigations on this halophyte to understand the suitable environmental parameters for maximum productivity of this plant in commercial scale. Soil samples were collected from different stations of the estuary to collect the information on soil salinity, soil pH and ratios of silt, clay and silt content in the sediments. Soil salinity varied from 24 to 34 ppt in all stations, pH of the soil samples varied from 7.6 to 7.9. Soil analysis shows the sand content varies from 9.0 to 18, silt 46 to 61 and clay 28 to 38. *Salicornia brachiata* is seasonal herb which completes its life cycle in eight to nine months. Maximum productivity was reported when salinity was in between 23 to 35 ppt, minimum percentage of sand and silt content was more than 50%. In the Godavari estuary maximum density (2884 plants/hectare) was reported for *Salicornia* populations in the Chollangi station followed by Pandi (2446 plants/hectare).In cultivation, biomass productivity was 15,000to 19,000 kgs per hectare and seed production 1200 to 1800 kgs per hectare.

Come out and claim the road

Sunita Narain*
Director General of CSE and publisher of Down To Earth, an environmentalist
New Delhi, India
<sunita@cseindia.org>

I write this column from my bed, recovering from an accident that broke my bones. I was hit by a speeding car when cycling. The car fled the scene, leaving me bleeding on the road. This is what happens again and again, in every city of our country, on every road as we plan without care for the safety of pedestrians and cyclists. These are the invisible users. They die doing nothing more than the most ordinary thing like crossing a road. I was more fortunate. Two cars stopped, strangers helped me and took me to hospital. I got treatment. I will be back fighting fit and this is one battle that needs our combined attention. We cannot lose the space to walk and cycle. Since my accident, relatives and friends all have berated me for being so reckless as to cycle on Delhi's roads. They are right. We have built the city roads only for cars. They rule the road. There are no dedicated lanes for cycles and sidewalks. The little stretches that do exist are either dirty or taken over by parked cars. Roads are for cars. The rest don't matter.

But cycling and walking are difficult not just because of poor planning. It is also because of our mindset that only those who move in a car have a status and road rights. Anyone who walks or cycles is poor, wretched and destined to be marginalized, if not obliterated. This is what must change. We have no option but to reinvent mobility, as I keep repeating. This week toxic smog in Delhi has reached a new peak. Last month the World Health Organization declared air pollutants a human carcinogen. We must realize that this pollution is not acceptable. It is killing us and no longer softly or slowly. But if we are serious about combating air pollution then we have no option but to think of restraining the growth of cars. Learn how to move people not cars.

When Centre for Science and Environment began its campaign against air pollution in the mid-1990s, it did everything conventional. It pushed to clean up the quality of fuel; improved emission standards of vehicles; got inspectional and maintenance systems for checking tailpipe emissions in place. It also pushed a leapfrog solution—transition to compressed natural gas (CNG) for gross polluting vehicles like diesel buses and two-stroke auto rickshaws. All that made a difference. There is no question that the quality of air would have been even worse, even more deadly, without these steps.

But this is not good enough. We soon realized this. Pollution levels are rising again, inexorably and inevitably. All research points to one cause and one big solution: building transport systems differently. We also have the option of doing this. We have still not motorized; still not built every flyover or four-lane road. Most importantly, most of India still takes the bus, walks or cycles—in many cities as much as 20 per cent population bikes. We do this because we are poor. Now the challenge is to reinvent city planning so that we can do this as we become rich.

For the past few years this is exactly what we have been working on—how to bring back integrated and safe public transport options to our cities, so that even if we own a car, we don't have to drive it. But the keyword is integration. We can build a metro or get new buses, but if we do not have last mile connectivity, then it will still not work. It has to be seamless and effortless. That is why we need to think differently.

This is where we are failing. Today, there is talk of transport, even cycling and needs of pedestrians. But it is empty talk. Every time there is an attempt to take a part of the existing road and convert it into a cycle track, it is virulently opposed. The argument is it will take away space from cars and add to congestion. But that is exactly what we need to do; reduce lanes for cars and add space for buses, cycles and pedestrians. This is the only way to get out of the ever-growing car-bulge on roads.

This takes courage of conviction. In our overcrowded and chaotic roads, planning for cycle tracks and keeping sidewalks clean and clear will take lots of effort. I have absolutely no illusion that this will be easy to plan or to implement. But why should that deter us? The rest of the world has learnt successfully to rework road space so that it provides dignity and accessibility to cyclists and pedestrians. They have learnt to restrict space for cars and yet build extremely liveable cites.

Just think of the double bonus: clean air by getting rid of the most noxious source of pollution and healthy bodies by having the option of getting some exercise while commuting. This is what we have to fight for. And we will. I hope all of you will join us in making the right to cycle and walk with safety non-negotiable.

*An Internationally renowned Environmentalist and Head of a prestigious NGO.

NEWS & VIEWS

Carcinogenic emissions from motorcycles

Polycyclic aromatic hydrocarbons (PAHs) and nitro polyclic aromatic hydrocarbons (NPAHs) are widespread pollutants in the environment which have been found in diesel particulates, fly ash, cigarette smoke and various incomplete combustion processes of organic matters and fossil fuels. Once released into the atmosphere, both PAHs and NPAHs can be carried over thousand of kilometers through the atmosphere from their original sources. Many PAHs and NPAHs are carcinogenic and/or mutagenic. Several NPAHs exhibit higher mutagenicity and carcinogenicity than their parent PAHs.

Internal combustion engines in motor vehicles generate a wide variety of particulate matter (PM), which are mainly fine particulates with a diameter smaller than 0.25 μm. When PM are inhaled, coarse particulates are deposited almost exclusively in the nose and throat, whereas fine and ultrafine particles generally are able to reach the lungs. Many carcinogenic PAHs and NPAHs have been found to associate with particulates, predominantly with fine particulates.

Motor cycles, which are two-wheeler vehicles, are popular means of transportation in South-East Asian countries. In some countries they account for more than 90% of total vehicles in urban areas. Exhausts emitted from motor cycles contribute significantly to levels of several air pollutants such as hydro carbons, carbon monoxide, nitrogen oxides and PAHs and NPAHs.

The characterization of PAHs and NPAHs from motorcycle exhausts, their relationship with regulated pollutants, and also their carcinogenic and mutagenic potencies are necessary to fully investigate to be helpful in emission control for motorcycles.

Source: C.T. Pham, T. Kameda, J. Hayakawa in *Environmental Pollution* 183(2013):175-183
Editor-in-Chief W.J. Manning

Herbal supplements may contain toxic contaminants

Majority of herbal products in the market contain ingredients not listed on the label, with most companies substituting cheaper alternatives and using fillers, a new study, including Indian researchers, claims.

The study from the University of Guelph in Ontario, Canada used DNA bar-coding technology to test 44 herbal products sold by 12 companies. Only two of the companies provided authentic products without substitutions, contaminants or fillers.

Overall, nearly 60% of the herbal products contained plant species not listed on the label, researchers said. Researchers detected product substitution in 32% of the samples. More than 20% of the products included fillers such as rice, soybeans and wheat not listed on the label. "Contamination and substitution in herbal products present considerable health risks for consumers," said lead author Steven Newmaster.

"We found contamination in several products with plants that have known toxicity, side effects and/or negatively interact with other herbs, supplements and medications," said New Master.

PTI
Hindustan Times

New greenhouse gas more effective than CO_2

According to scientists at Toronto University of Canada, Perfluorotributylam (PFTBA) , a newly discovered greenhouse gas is 7,000 times more powerful than carbon dioxide at warming the Earth. PFTBA, has been in use since the mid-20th century for various applications in electrical equipment, such as transistor and capacitors.

This chemical, that does not occur naturally, breaks all records for potential impacts on the climate. PFTBA has the highest radiative efficiency of any molecule detected in the atmosphere to date. Concentrations of PFTBA in the atmosphere are low–0.18 parts per trillion compared to 400 parts per million for carbon dioxide. So PFTBA does not display CO2 caused by the burning of fossil fuels as the drivers of climate change. But it is a warning to us that this gas could have a very large impact on climate change – if there were a lot of it, we have to make sure it dose not grow and become a very large contributor to global warning.

PFTBA remains in the atmosphere for about 500 years, and unlike carbon dioxide, that is taken up by forests and oceans, there are no known natural "sinks" on Earth to absorb it. A number of recent studies have drawn attention to other potential greenhouse gases which, like PFTBA, pack a lot of warning against increasing uses of such compounds without first understanding their impact on climate change.

Source: climatescience.com

Arctic Seafloor Methane releases more than previous estimates

Methane is a greenhouse gas more than 30 times potent than carbon dioxide. It is an important factor in global climate change, because it effectively traps heat. As condition warm, more methane is released, which then stands to further warm the planet.

According to the scientists of University of Alaska Fairbanks, the East Siberian Arctic Shelf is releasing at least 17 teragrams (a teragram is equal to 1 million tons) methane into the atmosphere each year. Previous estimates suggested that the area was releasing 8 teragrams of methane into the atmosphere yearly. Increased methane releases in this area are a possible new climate-change-driven factor that will strengthen over time.

On land methane is released when previously frozen organic material decomposes. In the sea bed, methane can be stored as a pre-formed gas or as methane hydrates. As long as the subsea

permafrost remains frozen, it forms a cap, effectively trapping the methane beneath. However, as the permafrost thaws, it develops holes, which allow the methane to escape. These releases can be larger and more abrupt than those that result from decomposition.

Recent Arctic expeditions have revealed that the subsea permafrost in the area has thawed much more extensively than previously thought due to warming water near the bottom of the ocean. The warming has created conditions that allow the subsea methane to escape in much greater amount than their earlier models estimated. Frequent storms in the area hasten its release into the atmosphere.

Source: Nature Geoscience

Ecological methods can help solve food insecurity issues

Adopting ecological approaches can help build resilient food systems in achieving food security in a changing climate. This raises the question of how ecological-based approaches will impact food systems. One of such approaches is ecosystem-based adaptation (EbA) which provides flexible, cost-effective, and broadly applicable alternatives for building robust food systems and reducing the impacts of climate change.

EbA is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels. It provides many other benefits to communities, including food security (from fisheries to agro-forestry), sustainable water management, and livelihood diversification (through increasing resource-use options).

Ecosystem degradation undermines food production and the availability of clean water, among other ecosystem services, thereby threatening human health, livelihoods, and ultimately social stability. Degradation increases the vulnerability of populations to natural disasters. To meet the food needs of today and tomorrow, ecosystem services, such as water provision, pollination, and maintenance of soil fertility must be enhanced. Farmers rely on soil microorganisms to maintain soil fertility and structure for crop production, and on wild species for crop pollination and pest and predator control.

Lessons learnt from EbA actions can help tackle the current food crisis. For example, in Xai Xai, Mozambique, many households were experiencing an average of four to five months of food shortage every year, affecting mainly fishers. Coupled with drought and changing climate, this coastal community needed to get food from other sources, such as sea. Ecosystem-based adaptation approaches such as fish farming, crab farming, and mangrove reforestation were used to address this food insecurity.

Mangroves provide a nursery area for many marine species, most of which are important for food, like fish, crabs, and shrimp. Reforestation of mangroves has ensured the normal functioning of this ecosystem, which has in turn increased fishery productivity and yield, ensuring enhanced food security.

Reorienting local food systems towards modes of production that are highly productive with ability to improve the sustainability of agro ecosystems by creating beneficial biological interactions and synergies among the different components is imperative. Investment in EbA is one of the most important keys to job creation opportunities that simultaneously contribute to poverty eradication and to sustainable long-term food security.

Source: Dr Richard Munang*
Guardian Professional

Arctic alpine plants may survive in 'micro refuges' as temperatures rise

Arctic alpine plants may survive in small pockets of cold, disturbed ground even if rising temperatures drive them from the rest of their habitat, according to researchers of Helsinki University Finland.

Where only the peak of a mountain is suitable for these alpine species, there's a lot of worry that as conditions warm and lowland species move up, they will essentially be squeezed off the top and be lost.

But there may be some respite. Scientist have found that the ground on the slopes around Saana fell in northern Finland varies hugely on a scale of just metres. Soil moisture, soil temperature, the amount of sunshine received, and disturbance from factors including wind, late-lying snow, water flow and seasonal permafrost all depend on the local landscape.

For example, the creep downhill of soil due to repeated freezing – also known as "solifluction" – can prevent crowberry, dwarf birch and juniper from growing in spots where they'd normally dominate. This gives Arctic alpine species a chance to move in. Such variation in local conditions could provide havens for Arctic alpine species as climate warms. Instead of keeping pace with temperature changes by moving hundreds of metres north or tens of metres uphill each year, these plants may find a patch of suitable ground nearby.

If a species needed to move to an area 2C cooler, it could move to just the other side of a boulder, going from a south-facing slope to a north-facing slope. Or to compensate for a change in moisture it could just move into a depression instead of being in a ridge. Such depressions would then act as microrefugia – small hideouts, may be just a few metres across – for cold-requiring species as climate warms, buying them extra time before extinction looms. Being able to shift just a small distance means that the outlook for these species is maybe not as bad as forecast, but it doesn't change the fact that the populations would be seriously affected by climate change. Even if cold-requiring or cold-tolerant species are able to continue existing on a certain hill, they might end up being much less connected to other populations of the same species, which has all sorts of implications for genetic diversity.

Source: Liz Kalaugher
The Guardian

*Policy & Program Co-ordinator for the Africa Climate Change Adaptation Program of the UNEP

CONFERENCES

International Conference of Environmental and Occupational Health (ICEOH 2014)
7– 9 April, 2014; Kuala Lumpur, Malaysia
Contact: Dr Shamsul Bahrin
E-mail: shamsul@medic.upm.edu.my
http://www.iceoh2014.org/iceoh2014

The annual Southwest Conference on Botanical Medicine
11 - 13 April, 2014; Tempe, Arizona
Contact: Herbal Educational Services,
PO Box 3427, Ashland, OR 97520
http://www.botanicalmedicine.org/conferences/sw2014/sw2014genl.htm#Contact

Energy Production and Management in the 21st Century – The Quest for Sustainable Energy
23 – 25 April, 2014; Ekaterinburg, Russian Federation
Contact: Genna West
Wessex Institute of Technology
Ashurst Lodge, Ashurst, Southampton, SO40 7AA
E-mail: gwest@wessex.ac.uk

7th International Conference on Waste Management and the Environment
12 - 14 May, 2014; Ancona, Italy
Contact: Irene Moreno Millan
Wessex Institute of Technology,
Ashurst Lodge, Ashurst
Southampton, SO40 7AA
E-mail: imoreno@wessex.ac.uk

5th International Congress on Arsenic in the Environment
11–16 May, 2014;
Ciudad Autónoma de Buenos Aires, Argentina
Contact: info@as2014.com.ar,
as2014.argentina@gmail.com
http://www.as2014.com.ar/registration.html

9th International Conference on Risk Analysis and Hazard Mitigation
4 - 6 June, 2014; New Forest, UK
Contact: Christine Young
Wessex Institute of Technology
Ashurst Lodge, Ashurst, Southampton, SO40 7AA
E-mail: cyoung@wessex.ac.uk

4th International Conference on Flood Recovery, Innovation and Response
18 - 20 June, 2014; Poznan, Poland
Contact: Christine Young
Wessex Institute of Technology
Ashurst Lodge, Ashurst, Southampton, SO40 7AA
E-mail: cyoung@wessex.ac.uk

6th International Conference on Climate Change: Impact and Responses
27- 28 June, 2014; Reykjavik, Iceland
http://on-climate.com/the-conference

22nd International Conference on Modeling, Monitoring and Management of Air Pollution
7 - 9 July, 2014; Opatija, Croatia
Contact: Genna West
Wessex Institute of Technology
Ashurst Lodge, Ashurst, Southampton, SO40 7AA
E-mail: gwest@wessex.ac.uk

Sustainable Tourism 2014
6th International Conference on Sustainable Tourism
8 - 10 July, 2014; Opatija, Croatia
Contact: Genna West
Wessex Institute of Technology
Ashurst Lodge, Ashurst, Southampton, SO40 7AA
E-mail: gwest@wessex.ac.uk

Water Resources and wetlands
2nd International Conference on Water resources and wetlands
11-13 September, 2014; Tulcea, Romania
Contact: Dr. Petre Bretcan, Organizing Committe
E-mail: petrebretcan@yahoo.com
http://limnology.ro/water2014.html

BOOKS

Principles of Terrestrial Ecosystem Ecology
Second edition
By Chapin III, F Stuart, Matson, Pamela A., Vitousek, Peter
Springer 2012
ISBN 978-1-4419-9503-2
Price: 149,95 €

Lichens to Biomonitor the Environment
(Eds) Shukla, Vertika Upreti, , D.K., Bajpai, Rajesh
Springer 2013
ISBN: 978-81-322-1502-8
Price: 99.99 €

Symplasmic Transport in Vascular Plants
(Eds.)Sokołowska, Katarzyna; Sowiński, Paweł
Springer 2013
ISBN: 978-1-4614-7764-8
Price: 139,99 €

Agroforestry Systems in India: Livelihood Security & Ecosystem Services
Advances in Agroforestry, Vol. 10
(Eds.) Dagar, Jagdish Chander; Singh, Anil Kumar; Arunachalam, Ayyanadar
Springer 2014
ISBN: 978-81-322-1661-2
Price: 149.99 €

Evolution of the Atmosphere, Fire and the Anthropocene Climate Event Horizon
Series: Briefs in Earth Sciences
By Glikson, Andrew Y.
Springer 2014
ISBN: 978-94-007-7331-8
Price: 49.99 €

Eutrophication: Causes, Consequences and Control, Vol. II
(Eds.) Ansari, Abid A.; Gill, Sarvajeet Singh
Springer 2014
ISBN: 978-94-007-7813-9
Price: 99,99 €

Advances in Agroforestry, Volume 10
Agroforestry Systems in India: Livelihood Security & Ecosystem Services
Springer 2014
(Eds.) Jagdish Chander Dagar, Anil Kumar Singh, Ayyanadar Arunachalam
ISBN: 978-81-322-1662-9
Price: $159.00

Use of Microbes for the Alleviation of Soil Stresses, Volume 1
(Ed.) Miransari, Mohammad
Springer 2014
ISBN: 978-1-4614-9465-2
Price: 139,99 €

Plant Litter
Plant Litter: Decomposition, Humus Formation, Carbon Sequestration
Berg, Björn, McClaugherty, Charles
Springer 2014
ISBN: 978-3-642-38820-0
Price: 149,99 €

Remediation of Contaminated Environments
(Eds) G. Voigt, S. Fesenko,
Elsevier Science
ISBN: 978-0-08-044862-6
Price: US$ 210.00

Physiological Mechanisms and Adaptation Strategies in Plants Under Changing Environment Volume 2
(Eds.) Ahmad, Parvaiz; Wani, Mohd Rafiq
Springer 2014
ISBN 978-1-4614-8599-5
Price: 169,99 €

Editors :
Dr. K.J. Ahmad
Prof. R.S. Tripathi
Prof. Mohammad Yunus

Printed and Published by :
International Society of Environmental Botanists, CSIR-National Botanical Research Institute, Rana Pratap Marg, Lucknow-226001, India
Tel. 0522-2297821: 2205831-35 **Extn.** 821
Fax: 0522-2205836

Email: isebnbrilko@sify.com
Website: http://isebindia.com