

## CHAPTER 15

### ENVIRONMENTAL STUDIES

#### Doctoral Theses

01. AHANGER (AB Majeed)  
**Synthesis and Characterization of Zeolitic Imidazole Framework-8 using Ajuga Species and their Applications.**  
Supervisor: Prof. Suresh Kumar  
Th 26053

#### *Abstract*

The bioactive compounds were isolated from the extracts of *Ajuga parviflora* Benth. and *Ajuga bracteosa* Wall. ex Benth. showed antibacterial activity against gram-positive and gram-negative bacteria. Herein, we report the design and synthesis of an unequivocal approach for encapsulation of extracts of *A. parviflora* and *A. bracteosa* within the ZIF-8, forming an APE@ZIF-8 and an ABE@ZIF-8 nanocomposite. The zeolitic imidazole framework-8 is a subfamily of the metal-organic framework that consists of highly crystalline, hybrid porous materials made by organic linkers and metal ion connectors with ultra-high internal surface areas, tunable shapes, uniform pore sizes, high thermal and chemical stability, and versatile functionality. ZIF-8, APE@ZIF-8, and ABE@ZIF-8 NPs were characterized using UV-vis absorption spectra, XRD, SEM, TEM, BET, TGA, DLS, and zeta potential. All these techniques support the idea that APE and ABE are encapsulated within the ZIF-8. The antibacterial effectiveness of APE@ZIF-8 and ABE@ZIF-8 nanocomposite compared to the control group was evaluated using different concentrations of ZIF-8, APE, ABE, methanol, and gentamicin at 1000 µg/mL-1, 750 µg/mL-1, 500 µg/mL-1, 250 µg/mL-1, 125 µg/mL-1, 62.5 µg/mL-1, and 31.25 µg/mL-1. The APE@ZIF-8 and ABE@ZIF-8 NPs showed three times more efficient compared to ZIF-8, APE, and ABE, methanol, and double that of gentamicin, against G+ and G- bacteria using their ZOI and MIC values. Positive-charged APE@ZIF-8 and ABE@ZIF-8 NPs are attached by electrostatic interaction with the negatively charged bacterial surface of *B. subtilis*, *S. aureus*, and *E. coli*, and *Pseudomonas aeruginosa* bacterial strains and induce ROS that damages cell organelles. Therefore, APE@ZIF-8 and ABE@ZIF-8 nanocomposites have infinite potential to treat infectious diseases caused by drug-resistant bacteria. ABE@ZIF-8 showed the highest anticancer activity compared to ZIF-8 and ABE against the alveolar cell (A549) cell line. It is expected that stellerol, bruceantin, squalene, phthalimide, stigmaterol, pregnenolone, and gaillardia to be responsible for antibacterial properties and bruceantin is responsible for anticancer properties.

#### *Contents*

1. Introduction 2. Review of literature 3. Materials and methods 4. Results and observations 5. Discussion 6. Summary 7. Conclusion. References. List of publications. Papers presented in conferences and seminars.
02. ARORA (Jaya)  
**Vegetation Dynamics of the Landslide-Induced Disturbed Habitats in Nana Devi Biosphere Reserve Area (Western Himalaya): An Ecogenomic Study.**  
Supervisors: Prof. Maharaj K. Pandit and Prof. Suman Lakhanpaul  
Th 26049

### Abstract

Ecological disturbances occur when the structure and composition of the forest ecosystems, as well as their functions and resource availability are altered. Landslides, are the frequent disturbances in the Himalayas that affect various ecosystems along the elevationa1 gradient. The consequences include removal of topsoil and disruption of stabilized communities. Ecologists are more concerned with plant colonisation and colonizing potential of plant species in degraded ecosystems, as well as their restoration. Therefore, it is important to understand the post-landslide natural colonization and soil characteristics at a temporal scale. The present study assesses landslide-induced disturbances and their impacts on vegetation, topsoil, genetic attributes and below-ground microflora in the Western Himalaya, India. Field studies were carried out in Nanda Devi Biosphere Reserve and Valley of flowers National Park in Alaknanda river basin of Uttarakhand. Plant community structure of ten landslide disturbed sites along a chrono-sequence of 1 to 25 years, within an e1evational gradient of 1400m to 3500m were investigated using line transect method. The neighbouring undisturbed forest community served as a control. My investigations revealed that species richness rapidly increased during the first few years of landslide disturbance, reached maximum at intermediate stage and then gradually decreased along the succession. 25-year old landslide had no significant difference in the species composition between its disturbed and control; indicating that disturbance was nearing senescence. Soils in the disturbed sites recovered with the passage of time, but the near-control soil environment seemed to take at least 25 years. Additionally, polyploids inhabited highly disturbed habitats while diploids preferred more stable habitats. Smaller genome size or genome downsizing was demonstrated in my studies related to *Geranium* spp. Disturbance however, seemed to be the principal driver of the differences observed in below-ground microflora associated with a set of congeneric species.

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1. Introduction and background 2. Vegetation community dynamics following disturbance 3. Changes in soil physico-chemical properties 4. Ploidy, genome and disturbance 5. Rhizosphere microflora of geranium spp. 6. Summary and conclusions. References and annexures.

03. KAUSHIK (Rishabh)  
**Bacterial Rhizobiome and Ecological Correlated of Native and Alien Invasive Prosopis Congeners.**  
 Supervisor: Prof. Maharaj K. Pandit  
Th 26048

### Abstract

Exotic invasive plants not only affect global biodiversity but also disrupt ecosystem functions and cause agricultural and economic losses. There is growing evidence that invasive plants alter the soil microbial communities to facilitate their establishment in the non-native ranges. Also, invasive plants have a better growth rate compared to the native plants which is mainly attributed to their higher water usage. *Prosopis juliflora*, an aggressive invasive plant in India has been listed among the top 100 global invasive plants by IUCN. In this study, I tried to decipher the bacterial rhizobiome associated with native *Prosopis cineraria* and invasive *Prosopis juliflora* along with their predictive metabolic profiles. Here, I found that the invasive *P. juliflora* shows a selective enrichment of bacterial communities belonging to plant growth-promoting phyla like *Actinobacteria*, *Acidobacteria*, *Chloroflexi*, *Firmicutes*, etc compared to its native congener as well as the surrounding bulk soil. Furthermore, the bacterial rhizobiome associated with the invasive *P. juliflora* shows a higher abundance of pathways associated with antimicrobial biosynthesis and degradation as well as secondary metabolite production. Soil feedback experiments suggest the presence of negative interactions in the case of native *P. cineraria* and positive interactions in the case of the alien *P.*

*juliflora*. Soil inoculation experiments using PJ1 (*Streptomyces pratensis*) and PC1 (*Streptomyces coelestis*) isolates on their respective hosts and reciprocally, showed that the plant growth was positively impacted in alien invasive *P. juliflora* and negatively impacted in native *P. cineraria* when grown on soils inoculated by their own respective *Streptomyces* bacterial isolates. Comparative investigations on transpiration rates and rhizosphere moisture measurements revealed that the invasive *P. juliflora* expends more water compared to its native congener, *P. cineraria*.

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1. Introduction 2. Comparative bacterial rhizobiomes 3. Comparative predictive metabolic profiles 4. Comparative plant growth performance and bacterial microbiome 5. Ecohydrology of native and alien Prosopis spp. 6. Summary and conclusions. Appendix and references.

04. PANKAJ KUMAR

#### **Role of Anthropogenic and Geogenic Processes in Heavy Metal-Induced Pollution and Associated Risks in Riverine Ecosystems.**

Supervisor: Prof. R. S. Sharma

Th 26045

#### Abstract

Abstract of the Ph.D. thesis on “**Role of Anthropogenic and Geogenic Processes in Heavy Metal Induced-Pollution and Associated Risks in Riverine Ecosystems**” submitted by Mr. Pankaj Kumar, Department of Environmental Studies, University of Delhi on 21 December 2021. Heavy metal pollution in riverine ecosystems has emerged as a major global threat to human and ecosystem health; however, current approaches do not provide realistic estimates of pollution and associated risks. Therefore, the current research was undertaken to: (i) assess heavy metal pollution and associated risks in aquatic ecosystems governed by anthropogenic and geogenic processes; (ii) ascertain metal remediation potential of *Cynodon dactylon* grass and *Morganella morganii* dead biomass; (iii) assess pan-India heavy metal pollution and associated risks in major rivers, and (iv) develop an evidence-based holistic framework for heavy metal monitoring in riverine ecosystems. In Yamuna River (Delhi), Pb, Cr, Cd, and Ni are found as major heavy metal pollutants of water, sediments, and floodplain soil, posing high ecological risks. Children are more vulnerable to carcinogenic/non-carcinogenic effects than adults. Native floodplain vegetation effectively reduces metal pollution and restores the quality of different environmental compartments in soil>sediment>water. In contrast, heavy metal concentration is not a major concern in Tatwani geothermal spring despite extreme geogenic activities. *C. dactylon*, which occurs naturally in floodplain, efficiently accumulated and partitioned Zn, Cr, and Pb in different plant parts. *M. morganii* dead biomass effectively biosorbed Pb(II) from water under varying physicochemical and shaking conditions with chemisorption as a dominant underlying mechanism. Meta-analyses of Indian rivers showed Cr, Cd, Ni, and Pb as major heavy metal pollutants of significant concern in the Damodar, Ganga, Gomti, Hindon, Krishna, Narmada, Satluj, Tapi, and the Yamuna Rivers, which pose cancer risks in adults and children. Current monitoring and assessment practices for metal pollution in rivers lack a holistic approach. Therefore, the ‘Five-wheel framework’ is developed based on an experimental design that integrates interactions among river environmental compartments besides land use and provides realistic estimates of pollution and associated risks to ecosystems and humans.

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1. Introduction 2. Understanding heavy metal pollution and associated risks in an aquatic ecosystem governed by anthropogenic processes 3. Understanding heavy metal pollution and associated risks in an aquatic ecosystem governed by geogenic processes 4. Assessing phytoremediation potential of *Cynodon dactylon* (L.) Pers. grass naturally occurring at Yamuna river floodplain (Delhi) using a chemometric approach 5. Assessing Pb (II) biosorption potential of dead biomass of *Morganella*

morganii from aqueous solution 6. Assessing pan-India heavy metal pollution and associated risks in the water of major rivers 7. Assessing pan-India heavy metal pollution and associated risks in the sediments of major rivers 8. An evidence-based holistic framework for heavy metal monitoring in riverine ecosystems. Summary and conclusions. References and appendix.

05. SANA REHMAN

**Multi-Species Occupancy Modeling Study of Common Waterbirds in Response to Habitat Variables in the River Yamuna of Delhi.**

Supervisor: Prof. A. J. Urfi

Th 26054

*Abstract*

The rapid and often unplanned growth of urban centers throughout India, has led to a significant decline in remnant habitat patches which are often used by wildlife. These urban patches played an extremely important role in providing habitat for the flora and fauna. Many animals have been affected by the urban sprawl including plants, mammals, amphibian and reptiles and birds. Given that ecological knowledge of large urban river systems is extremely sparse due to logistics and accessibility, an occupancy modelling study was conducted on the resident birds of Delhi. River Yamuna passing through Delhi is a refuge for several resident and migratory species of birds but its water quality has been deteriorating due to ever growing population, contributing most of its pollution load in the urban center. *Chapter 1* gives a brief introduction to urbanization and urban water birds and detail of importance of wetland as a habitat for birds. Here, we also discussed the objectives of this study, which were to determine whether the occupancy of common waterbirds varied between differential polluted sections of the river, to better understand the associations between habitat variables and use of the river habitat by common waterbirds, to identify whether any species or groups of species could be useful as indicators for habitat quality and to determine if the occupancy going to change if the surveys were done within a year or across the years. *Chapter 2* presents a short literature review on the importance of river Yamuna as habitat for resident and wintering water birds in Delhi. It also discusses the lack of conservation studies on the river as well as importance of planned scientific studies on river which is a habitat many ecologically important birds. We also discussed brief account of the degree of pollution in the river in recent years which is compelling birds to avoid this habitat such as Sarus Crane. We also discussed several birds as bioindicators that may either represent a particular ecosystem or various phenomenon and ecological functions and systems in that ecosystem. We also discussed about birds in urban ecosystem reacting to changes in the water quality. In this chapter, we discussed the details about the Mackenzie et al. 2002 model and use of Program 2 Presence in estimating the detection probability and occupancy probability. We also provided the details of extensive literature review of publications on occupancy modelling using various programs and details of using various covariates in the literature. *Chapter 3* gives the detail account of methods used during the study, using the Single season occupancy analysis. The occupancy parameter  $\Psi$  and detection probability  $p$  was estimated for common resident species among on the banks of river. In this chapter we described in detail. The choice of habitat variables for conducting the analysis. We also discussed the methods used for estimating the variables. The Species occupancy was estimated as a function of habitat variables such as physico-chemical characteristic of water such as dissolved oxygen, total dissolved solute, pH and other habitat parameters such as solid waste, percent area of surface and emergent vegetation and human disturbance at each sampling site using Single season Occupancy analysis using Program Presence ver. 5.8 (Hines 2006). We conducted the survey on 76 sampling locations over a 102-km stretch of the Yamuna River, including the Delhi section as well as contiguous sections up and downstream. We recorded the presence/ absence data of birds and habitat variables at 176 sampling locations on the banks of the river Yamuna. In this chapter, we also discussed about various methodological caveats during the course of the study. *Chapter 4* represents the results during the course of the study. Here, we gave brief accounts of physico-chemical parameters detected in the year 2018 and 2019. We also described the number of species spotted during the course of the study in the study area. The occupancy parameter  $\Psi$  was estimated for 17 common resident species among 68 species in 2018 and 71 species in 2019, recorded from 176 sampling locations, respectively on the banks of river. We also reported the detection

probability of the birds using Program Presence. We also reported the association of estimated occupancy parameter with various habitat parameters. According to analysis which suggest that Little Grebe (*Tachybaptus ruficollis*), Grey Heron (*Ardea cinerea*), Grey-headed Swamphen (*Porphyrio poliocephalus*), Eurasian Coot (*Fulica atra*), Common Moorhen (*Gallinula chloropus*), Purple Heron (*Ardea 3 purpurea*) and Little Cormorant (*Microcarbo niger*) are negatively associated with the Total Dissolved Solute (TDS). Interestingly, occupancy of Black-winged Stilt (*Himantopus himantopus*) is negatively associated with pH but positively with solid waste strongly suggesting its preference for the polluted sections of the river, possibly due to the increased availability of food. Several birds were also associated with dissolved oxygen content of the water body with Little Cormorant showing the highest association. In this chapter, we discussed in detail about the differential utilization of the riverine habitat by various birds. Fewer birds use the downstream habitat as there is a huge decline in the water quality of the river after Wazirabad in Delhi. *Chapter 5* discusses various outcomes of the study as many birds showed preference towards comparatively clean water, among them Eurasian Coot (*Fulica atra*), Great Cormorant and Little Cormorant both essentially fish dependent species, showed considerable difference in the occupancy. The occupancy probability of Little Grebe, Little Cormorant, Great Cormorant, Indian Pond Heron, Little Egret, Common Moorhen, Eurasian Coot, Grey-headed Swamphen, Red-wattled Lapwing, Black-winged Stilt, Common Sandpiper and White-throated Kingfisher was slightly higher if the surveys were conducted across years. For river Yamuna, estimates of  $\Psi$  for various birds forms a baseline to study future trends. *Chapter 6* presents various conclusions which can be draw from the study which indicates that species like Black-winged Stilt, can serve as a possible indicator of contaminated water bodies. The challenges posed by increasing urbanization and pollution to riparian bird habitats in urban areas can be effectively dealt with by incorporating such ecological knowledge with habitat restoration and conservation efforts. We also want to discuss the potential of occupancy modelling for conservation studies and city planning, emphasizing the importance of wetland habitats with respect to birds.

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1. Introduction 2. Literature review 3. Materials and methods 4. Results 5. Discussion 6. Conclusion. References. Appendices and list of publications.

06. SUMAN RANI  
**Assessment of Heavy Metal Level in Medicinal Plants and Cd-Induced Physiological Effects in Catharanthus Roseus.**  
 Supervisor: Dr. Rama Sisodia  
Th 26052

#### Abstract

Indian subcontinent possesses a rich diversity of plants that have been used in enhancing immunity as well as in treatment of a wide variety of ailments. Medicinal plants based therapeutics offer the advantage of safety, lesser side effects, efficacy and reduced costs. An analysis of the factors affecting the medicinal plant trade in India revealed that heavy metal contamination is an issue that is undermining its growth. Samples of selected medicinal plants were collected from a major MP trade market and analyzed to determine the heavy metal content and the health risk posed by consumption of the contaminated material. Heavy metals were detected in the samples tested; however, these were within permissible limits and the samples were therefore found safe for consumption. As a second part of the study the effect of the heavy metal cadmium was studied on growth and physiology of the medicinally important plant – *Catharathus roseus*. Bioaccumulation of the metal in different plant parts was accompanied by changes in ultrastructural changes in organelles such as chloroplasts

which included disorganization of thylakoid structures, accumulation of starch and plastoglobuli. Changes were also noted in total phenolic, malonaldehyde and proline content accompanied with change in activities of enzymes such as superoxide dismutase, catalase and peroxidase involved in ameliorating oxidative stress. The detailed metabolic profiling using gas chromatography mass spectroscopy revealed that the Cd tolerance of *C. roseus* can be attributed to the differential accumulation of the secondary metabolites such as alkaloids, terpenes, sterols and isoprenoids in *C. roseus* in response to Cd treatment. These metabolites aid in mitigating the metal induced oxidative damage by ensuring cellular ionic homeostasis, stabilizing membranes, cellular structures and essential processes. The study provides an insight into the issue of heavy metal induced changes in *C. roseus*.

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1. Introduction 2. Heavy metal contamination of medical plants in India – a perspective 3. Assessment of heavy metal load in medicinal plants collected from a major wholesale market of India 4. Cadmium mediated modulation of growth and physiology of medicine plant catharanthus roseus 5. GC-MS based metabolite profiling of medicine plant – catharanthus roseus under cadmium stress. Conclusion. Appendix and list of publications.

07. TIWARI (Chandranshu)  
**Katyids of India: Bioacoustics and Behavioral Ecology.**  
 Supervisor: Dr. Swati Diwakar  
Th 26051

#### Abstract

I describe the katydid acoustic community from biodiversity hotspot regions on India. I investigated possible drivers for spatial and temporal pattern of sympatric species at two locations in North-East Himalayas. I also compared the seasonal and habitat based transition in sympatric communities in North-East Himalayas (HGWS1) and Western Ghats (BMWS2). Individual insects were located through visual scanning/listening. Katyids were recorded using solid state recorder and analysed on signal processing software. I made a presence-absence matrix for 526 individuals based on transects laid in different habitats. I compared the community composition between habitats using multivariate analysis. I described calls for 23 species from five subfamilies viz., Conocephalinae, Mecopodinae, Hexacentrinae, Phaneropterinae, Pseudophyllinae. I reported first call descriptions for 18 species. Of the recorded species only four had narrow bandwidth while 20 exhibited broad bandwidth calls. Of the species, 9 had chirping calls, 6 had trilling calls and 11 had buzzing calls. Call types from the same habitats in HGWS and BMWS clustered in multidimensional space. The overlap in communities in indicate the influence of environmental conditions on the acoustically active community. I investigated the influence of crypsis, gender and effect of habitat in the predator avoidance in six species. I tested avoidance behaviour through two sets of treatment: Physical disturbance, where individuals were exposed to increasing intensity of perch disturbance, and Acoustic playback of social and foraging echolocation calls of a sympatric bat species. There were no significant differences in avoidance behaviour between genders in any species. There was no correlation between the size and degree of caution. Grassland species were found to be more sensitive to physical disturbance, understorey species were found to be more sensitive to acoustic cues. I propose that habitat plays a determining role in the evolution of avoidance behaviour.

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1. Introduction 2. Singers in the grass: Call description of conehead katydid (family: Tettigoniidae) and observations on avoidance of acoustic overlap 3. The katydid

country: Bioacoustics and ecology of tettigoniid communities for the Indian subcontinent 4. Predator avoidance behaviour in sympatric katydid species 5. Conclusions and future directions. References. Appendices. List of publications and conferences.

08. TRIPATHI (Indu)  
**Status of Major Nutrients in Horticultural Systems in Kumaun Himalaya, Uttarakhand.**  
 Supervisor: Prof. K. S. Rao  
Th 26046

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1. Introduction 2. Soil fertility status of horticultural fields selected along altitudinal gradient in Kumaun Himalaya, Uttarakhand, India 3. C, N and micronutrient concentrations in litter samples from horticulture fields located along an altitudinal gradient in Kumaun, Uttarakhand 4. Role of Horticulture in supporting food security in Hilly regions of Uttarakhand, India as depicted by doing economic analysis in the horticultural fields 5. Post-harvest changes in nutraceutical properties of major fruit, that is, apple. Cultivated in Mukteshwar, Uttarakhand, India 6. Summary and conclusion. References.

09. TYAGI (Shipra)  
**Assessment of Organochlorine Pesticide and Heavy Metal Residues as an Emerging Environmental Risk Factor for Etiology of Diabetes Mellitus.**  
 Supervisor: Dr. A. J. Urfi  
Th 26050

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1. Introduction 2. Aim and objective 3. Review of literature 4. Material and methods 5. Results 6. Discussion 7. Conclusion of the study 8. Strength, limitations and future aspects. Bibliography and appendices.

10. VASHISTHA (Gaurav)  
**Habitat Degradation, Habitat Restoration Measures and Conservation of an Insular Population of Piscivorous Crocodile Gharial (Gavialis Gangeticus) at Katarniaghat Wildlife Sanctuary.**  
 Supervisor: Prof. David Kothamasi  
Th 26047

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1. Introduction 2. Gharial nesting in a reservoir is limited by reduced river flow and by increased bank vegetation 3. The effectiveness of microsatellite DNA as a genetic tool in crocodylian conservation 4. Anthropogenic restocking of gharial individuals prevents genetic isolation of gharial population in Girwa river, India by geographic barriers imposed by a barrage 5. Sand Addition promotes gharial nesting in a regulated river-reservoir habitat. General discussion and references.