

FOREST ECOSYSTEM: CARBON SEQUESTRATION AND ROLE IN INDIAN ECONOMY

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India is the world's fourth largest economy and fifth largest greenhouse gas emitter, accounting for about 5% of global emissions. For the Indian economy, which mainly depends on natural resources, climate change represents an additional stress on agriculture, forestry, water resources and human health. Known for its diverse forest ecosystems and mega diversity, the country ranks 10th amongst the most forested nations of the world with 23.4% of its geographical area under forest and tree cover.

Forests play an important role in environmental and economic sustainability providing numerous goods and services, and maintaining life support systems essential for life on earth. Forests meet nearly 40 per cent of the country's energy needs and 30 per cent of the fodder needs. Still forests are consistently and seriously undervalued in economic and social terms. In 1996-97, the contribution of the forestry sector to gross domestic product (GDP) was only 1% while the latest estimates show that forestry sector puts its contribution to GDP at 2.37%.

Besides providing various ecosystems goods and services, the role of forests in carbon sequestration has significantly increased the importance of forestry as a climate change mitigation strategy. Terrestrial carbon dynamics are characterized by long periods of small rates of carbon uptake, interrupted by short periods of rapid and large carbon releases during disturbances or harvest. Forests, particularly tropical, contribute more than other terrestrial biomes to climate relevant cycles and processes.. Globally forests store more than 55% of the global carbon stored in vegetation and more than 45% of that stored in soils. Approximately 1 trillion tons of CO₂ is stored in the biomass of living trees and plants. Recent studies suggest that about 11 million hectares of forests each year are lost in tropical regions due to deforestation and conversion of land to agriculture resulting in the emissions of about 3.6-4.5 billion tons of CO₂, so that deforestation accounts for around 17% of global carbon emissions. In Indian context, the recent estimates suggest that in a period of 10 years, from 1995 to 2005, there is an annual increment of 37.68 million tonnes in carbon stocks stored in Indian forests which means an annual removal of 138.15 million tonnes of CO₂ eq. It would be possible to increase this carbon efficiently by adopting the methods of afforestation, reduced deforestation, and forest management.

Several studies claim forest ecosystem services to be of great economic value and in valuation studies, ecosystem services values like carbon storage or hydrological protection are frequently claimed higher than forest products or alternative land uses. From a technical standpoint, standing tropical forests may contain 300-400 tons CO₂ per hectare in biomass. If carbon prices are \$14 per ton CO₂, the annual rental value of the carbon embodied in a standing tropical forest with 350 tons CO₂ in measureable aboveground carbon is \$245 per hectare per year. These estimates imply that avoided deforestation can be a low cost option that can meaningfully be applied to climate policy. There is a surprisingly wide range of options available to increase carbon through forest management providing benefits both in near and longer terms. Planting forests rather than relying on natural regeneration can increase the rate of carbon accumulation in early years and increase the overall quantity of carbon on the site in the long run. Several studies so far suggest that forest actions can cost effectively provide roughly 30% of the total global effort needed in all sectors to meet climate mitigation strategies.

Integration of REDD mechanisms in forest governance reform processes that aim to clarify and secure the rights of forest-dependent communities can facilitate the equitable sharing of benefits, and promote sustainable forest management. As a component of the National Action Plan for Climate Change, implementation of the National Mission for a Green India can further enhance the present mitigation potential of the forestry sector.

Key words: forest ecosystems, carbon sequestration, GHG emissions, economy, ecosystem services

CLIMATE CHANGE AND HYDRO-METEOROLOGICAL DISASTERS: ADAPTATION AND MITIGATION STRATEGIES

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The global, regional and local environment is changing due to many kind of anthropogenic activities such as green house gas emission, change in land use pattern, deforestation etc. The collective effects of such environmental changes result into climate change. The fourth assessment report of IPCC has clearly indicated the change of the temperature both over the land and ocean. As a result, the impact of disasters such as tropical cyclones, drought, flood and extreme temperature events etc. have an increasing trend with time. Impacts of such disastrous hydro-meteorological disasters may be direct or indirect and short-lived or long-lived. Climate Change exacerbates the frequency and intensity of hydro-meteorological disasters. Disaster risk management (DRM) and Climate change (CC) adaptation greatly overlap and can strategically reinforce each other

Hydro-meteorological events occur more frequently and are more widespread throughout South and South East Asia, where major river basins flood on an annual basis, island countries such as

Sri Lanka, Indonesia and the Philippines experience yearly flash floods and landslides, drought is a recurring phenomenon in India, Pakistan, Laos, Vietnam and Thailand, and typhoons regularly threaten coastal communities in Vietnam, the Philippines, India and Bangladesh. Problems associated with hydro-meteorological events such as water shortages, water contamination and migration of populations, further exacerbate hazard-related stress in urban areas. Improved uses of weather and climate information and forecasts have the potential to reduce risks of such disasters if proper early warning systems are in operation at national and international levels.

There is an intimate relationship of climate fluctuations and consequent human responses such as migration, adaptation and mitigation. Adaptation includes changes to social and cultural structures or more within society, so that vulnerability to climate variability and potential extreme events is reduced. Adaptation should build on previous experiences in relation to disaster management. Adaptation can be structural, such as the building of dykes or levees to combat flooding or sea level rise associated with climate change. Adaptation can also take the form of policy measures or approaches such as integrated coastal zone management. Adaptation strategies are, thus, a very important part of climate change management. This paper reviews the past and present scenarios of hydro-meteorological disasters along with implications of climate change on hydro-meteorological disasters and suggestive steps towards disaster risk management and adaptation strategies.

Key words: Hydro-meteorological disasters, vulnerability, climate change adaptation

BIODIVERSITY IN ORNAMENTAL PLANTS AND ITS COMMERCIAL IMPORTANCE

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A wide range of agro climatic conditions blended by different geographic distribution of various ornamental plants in different states of our country played significant role in development of broad spectrum of biodiversity. It can be assessed by observing their form, colour and size. Present paper deals with

biodiversity of some important commercial crop which are directly linked with multi million dollar floriculture industry and cut flower trade. The present paper deals with important ornamental plants and its available biodiversity viz. Bougainvillea, chrysanthemum, gladiolus, gerbera, hibiscus, Jasmine, Marigold, rose and tuberose. A survey on garden chrysanthemum reveal that approximately 1/3 of the garden chrysanthemum cultivar evolved as a spontaneous mutation. Plant breeders applied the available techniques to enhance the biodiversity by using polyploidy, hybridization, mutation breeding, tissue culture (Somaclonal variants) and by raising transgenic plant. Blue rose is one of the best examples of it.

Key words: Biodiversity; Ornamental plant; floriculture

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IMPACTS OF ALIEN INVASIVE PLANT SPECIES ON THE BIODIVERSITY OF ARAVALLIS, RAJASTHAN

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All over the world, the alien invasive species have been identified as an agent of the loss of native biodiversity. The paper gives an account of alien invasive species of Aravallis of Rajasthan. The Aravalli range which is the oldest range of folded mountains in the world has high endemic plant diversity but during the last decades, ecological conditions in Aravallis have dramatically changed; very evident is the biological invasion by invasive species, which has resulted in a modification of regional biodiversity. In the present study, survey was undertaken in different regions of Aravallis for identification of invasive species. Important alien invasive species of Aravallis are mentioned along with their nativity. The paper provides a general framework to describe patterns of plant invasion, factors and activities responsible for transportation of alien species. Globalization, improved technology and transportation are major contributor to plant invasions. Factors like land degradations, human transportation corridors and natural disturbances provide ground for establishment and growth for invasive species. An attempt has been made to discuss the harmful impacts of invasive species on native biodiversity of Aravallis as introductions of non indigenous invasive species have impaired ecosystem, increased the risk of native species extinctions and caused substantial economic damages. Therefore, the paper focuses on varied methods and technologies which could be used in future for early detection of aliens, to stop accidental immigration in foreign lands, treatments for eradication and restoration techniques.etc.

Key words: Alien invasive species; Aravallis; Biological invasion; Restoration techniques.

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PHYTO-DIVERSITY IN DRY DECIDUOUS FOREST OF THE CENTRAL ARAVALLI REGION OF RAJASTHAN

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This study deals with the plant diversity and effects of disturbance on dry deciduous forest of the Central Aravalli Mountains namely, *Anogeissus pendula* forest (350–650m asl) in Ajmer District of Rajasthan. A detailed phyto-diversity inventory was done on this forest to assess the floral biological diversity. In the present scenario, the dry deciduous forests are prone to high anthropogenic disturbances, which bring out loss and extinction of valuable species. However, some patches are protected due to efforts made by the state government, which can be categorized as moderately disturbed forest. The study showed that these moderately disturbed areas still favoured density and species richness in the forest. The Shannon diversity index and Simpsons index exhibited a similar trend, the highest value in moderately disturbed patches and

lowest in highly disturbed patches. A sharp decline was recorded in tree density and basal area with increasing disturbance magnitude in the dry deciduous forest of the central Aravallies.

Key words: Dry Deciduous forest, Phyto-diversity, Shannon diversity index and Simpsons index.

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BIODIVERSITY OF SALINE AND WATERLOGGED ENVIRONMENTS AND UTILIZATION OF SELECTED SPECIES IN AGRO-ECOSYSTEM

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Biodiversity is often defined as the variety of all life forms—the different plants, animals and micro-organisms; the genes they contain and the ecosystems of which they form a part. It is not a fixed entity, but constantly changing and increased by genetic changes and by evolutionary processes and reduced by extinction and habitat degradation. The concept emphasizes the inter-relatedness of the biological world covering the terrestrial, marine and other aquatic environment. Without going in details of types of biodiversity like specie (alpha), habitat (beta), landscape (gamma) and genetic diversity a brief general account of biodiversity of salt lands of India has been given in this paper which includes both inland and coastal (mangrove) habitats.

In India about 6.7 million ha land is suffering from degradation due to salinity and alkalinity problems. These lands occur under different environmental conditions and have different morphological, physical, chemical and biological properties. As per estimate of Ministry of Water Resources in canal command areas of the country 2.46 million ha area is waterlogged and 3.30 million ha is salt-affected and secondary salinization is rapidly increasing in irrigated areas. These saline soils are universally low in fertility and difficult for conventional agricultural use. Sub-surface drainage is the most effective tool to wash out salts in saline soils, but this method is costly and cannot be adopted in the entire area. However, such lands can effectively be utilized for salt-tolerant biological system. A survey conducted by traversing inland and coastal saline areas in India has indicated the occurrence of about 1140 vascular plant species distributed under 541 genera and 131 families. The maximum number of inland salt-tolerant (showing no yield reduction up to EC_e or EC_{iw} 8 dS m^{-1}) species have been found in Poaceae with 131 species followed by Papilionaceae (67 species), Asteraceae (55), Mimosaceae (53), Cyperaceae (52), and a family with true halophytes Chenopodiaceae with 48 species. In this list many species of *Acacia*, *Eucalyptus*, *Atriplex*, *Prosopis*, and *Casuarina* are exotic to India, and represent 34, 25, 13, 11, and 10 species, respectively. Many of these species are surviving well in salt-stressed localities. All the members of Chenopodiaceae, Rhizophoraceae, Avicenniaceae, Salvadoraceae, Sonneratiaceae, and Tamaricaceae families are true halophytes and tolerate salinity as high as that of sea water or even higher when found in inland-saline conditions.

Along coasts in tidal zone 37 species are exclusive mangroves and about 7 dozen species are associate mangroves distributed in 4533 km² mangal formation zone. Mangroves inhabit the intertidal estuarine regions, sheltered coastlines, lagoons, and creeks. Their prop and knee roots protect the coast-line from erosion and help in dissipating the incoming wave energy and saving disasters during cyclones and Tsunami all along the coast. The complex root system not only protects the shore-line but the roots and branches also trap nutrition in the form of litter and serve as shelter and food for a large number of organisms including many beautiful orchids, ferns, lichens, mosses, jungerminiales, algae, fungi, ciliates, nematodes and amphibians. Several interesting animals such as salt water crocodiles, turtles, water monitor lizards, snakes, wild pigs, monkeys, deer, even tigers (in Sunderbans), several indigenous and migratory birds, mud skippers, mollusks, insects and several crustaceans make the food chain very complex and interesting. This vast diversity of flora in addition to providing food for different kind of fauna also provides livelihood for the people inhabiting these areas particularly the tribal people.

In recent years, however, the attention is being paid worldwide to accommodate the salt tolerant species of industrial importance for highly saline degraded areas including coastal marshes. Some oil yielding species such as *Salicornia bigelovii*, *Salvadora persica*, *S. oleoides*, *Terminalia catappa*, *Calophyllum inophyllum* and *Pandanus* spp. are important and can be grown in highly saline areas irrigating with sea water or water of high salinity. The Palmyra palm (*Borassus flabellifer*) common in coastal areas is a source of alcoholic beverages, vinegar, toddy, jaggery and confectionery syrup. The Alexandrian Laurel (*Calophyllum inophyllum*) is essentially littoral and good source of seed oil used for soap making and skin infections. *Cynometra ramiflora* yields medicinal oil used for leprosy. *Nypa fruticosa* is a mangrove palm found in mangrove swamps of Andaman & Nicobar Islands and valued for its sweet sap which may be used for making jaggery, alcohol and vinegar while the leaves are used for thatching. Kair (*Capparis decidua*) is found on sand dunes and saline arid regions. Its fruits are medicinal and valued for commercial pickles. Neem (*Azadirachta indica*) is well known for its medicinal value and thrives well on Vertisols and calcareous saline soils irrigating with saline water up to 10 dS m⁻¹. Jojoba (*Simmondsia chinensis*) is considered a gold mine for desert and yields oil like sperm-whale from its seeds. It thrives well on sandy soil and may be irrigated with saline water of 10 dS m⁻¹. Medicinal and aromatic species such as Isabgol (*Plantago ovata*), *Aloe vera*, *Citrullus colocynthis*, Senna (*Cassia angustifolia*); essential oil yielding *Matricaria chamomilla*, *Vetiveria zizanioides* and *Cymbopogon flexuosus*, *C. martinii*; flower yielding *Chrysanthemum indicum*, *Calendula officinalis* and *Dahlia rosea*; and petro-crops such as *Euphorbia antisiphilitica* and *Jatropha curcas* have been cultivated successfully on calcareous soil irrigating with saline water of 10 dS m⁻¹. Different varieties of Isabgol and Lemongrass have been evaluated for their salt tolerance and suitable cultivars have been identified. Agronomic practices for Isabgol, Lemon grass, vetiver (*Vetiveria zizanioides*), castor (*Ricinus communis*), dill (*Anethum graveolens*), taramira (*Eruca sativa*) have been evaluated with saline water of ECiw 10 dS m⁻¹. There are many other salt tolerant fruit, forage and fuelwood species, which have been tried and found suitable for highly saline situations. The scopes of many of these species of industrial application for rehabilitation of saline and sodic habitats along with their management and utilisation have been discussed in this paper.

Key words: Biodiversity, soil salinity, restoration

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THE CONCEPT OF ECOSYSTEM AND ITS LIMITATIONS – A COMMENTARY

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The term ecosystem was coined and categorically defined by AG Tansley in 1935. At that point of time ecosystem concept could provide a holistic approach to study the ecological problems. But subsequently it was found that ecosystem considers only the physical and biological parameters of environment but the role of man and his society is a taboo in that system. Man has now become the most dominant species and who is disregarding the cybernetic principle. Odum (1971) stated, “It is man the geological agent, not so much as man the animal, that is too much under the influence of positive feedback, and, therefore must be subjected to negative feedback” in order to maintain the homeostasis of ecosystem.

In order to obviate the inherent drawback of ecosystem concept which overlooked the role of man and his society, Barrett (1985) proposed a new philosophical outlook termed NOOSYSTEM which advocates a holistic paradigm. According to him the NOOSYSTEM is preferable to ECOSYSTEM concept as because the former integrates biological, physical and socioeconomic parameters within a framework of holism. According to Beck (1995) “we need to shift the focus of our understanding and research on the process of ecological degradation from the physical and natural sciences to an analysis of the social origins of ecological degradation”. Duncan (1961) developed POET model to describe the relationship between social factors and the natural environment. In this model P stands for human population, O for social organization, E for natural environment and T for technologies employed by society. Ehrlich and Holdren (1971) postulated the IPAT model where impacts of human society on the natural environment were indicated and sequentially the three variables are P-Population, A-Affluence and T-Technological

development. It has now become obvious and obligatory to unfold the social dimension of ecological science so as to ensure the survival of man and biosphere in space and time.

Key words: Ecosystem concept

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IMPACT OF URBANIZATION ON ANURAN FAUNA IN BARAK VALLEY, NORTH EAST INDIA

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Urbanization is a global trend and the Barak Valley region of South Assam is experiencing rapid urbanization. Urbanization is known to have negative influence on the wild flora and fauna. It leads to alteration of habitat structure as well as quality which in turn influences distribution and survival of anuran fauna. Barak Valley region of northeast India is a part of the Indo-Burma hotspot, which is one of the 34 global biodiversity hot spots. The region abounds in wetlands, tanks and ponds of varying sizes, streams, pools, marshes and others aquatic habitats; paddy fields and low hills. Agriculture and tea cultivation are important economic activities. However, development and expansion of urban areas is taking place at a fast rate in the region.

The paper analyses the impact of urbanization and related activities on the habitat loss and degradation and puts forward some suggestions which would help design conservation strategies for this lesser studied group of vertebrates.

Key words: urbanization; anura; habitat degradation; fragmentation; conservation.

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CONSERVATION OF MANGROVE BIODIVERSITY: A CHALLENGE IN THE SINDHUDURG DISTRICT OF MAHARASHTRA STATE

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Conservation of mangrove biodiversity is of prime importance. However, the status of mangroves of Maharashtra is alarming. The ecosystem is represented by 25 typical mangrove species, 11 halophytes and 10 associates. The present paper deals with conservation of threatened mangrove species, a case study in Sindhudurg district. It reports Khavane, as a new location of *Heritiera littoralis* which is a new record for the state. This species was not known from the west coast of India. Since 1999, nine new mangrove species have been reported from the state. The population size of the species, such as *Xylocarpus granatum* and *Heritiera littoralis*, is very small. These species are going to disappear soon. The later species is represented by a single individual. It needs urgent steps to be taken for its conservation. There are several causes of threatening, such as encroachment, clear felling, dredging etc. These and other species of mangroves are the elements of gene pool and demand immediate conservation measures. The present paper deals with different threats and the status on mangroves along coast of Sindhudurg district.

Key words: Biodiversity; mangroves; conservation; challenge; threat.

WATER QUALITY AND INDIAN LEGISLATION

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Water resource management is a State and concurrent subject under schedule VII of the Indian constitution. There are numerous institutions dealing with water resource management both at central and state level like Ministry of Water Resources, Ministry of Environment and Forests, Central and State Groundwater Boards, Ministry of Agriculture, Ministry of Industry, State Irrigation Departments and Central and State Pollution Control Boards.

Despite the enactment of laws, water pollution continues unabated, pointing to an obvious failure of policy and legislation. The pollution control staff are poorly staffed, lack technical facilities to control and prevent pollution and have meager financial resources. A lack of willingness to implement policy is also apparent. They have also failed to bring offenders to book. Thousands of cases have been initiated against polluting industries, but only a handful of convictions have been obtained. For example in Rajasthan only two convictions have been obtained, despite nearly 7,000 cases filed in court against air and water polluters.

The present policy relies on industry specific effluent standards, which are prescribed based on best available technology. Naturally, industries do not reveal what is possible and manage to get a lax standard. The volume of water used is taxed. The cess charged is not meant to concentration of pollutants, but to reduce quantity of waste water released through water conservation.

Though the pollution control boards routinely monitor the quality of water in lakes and rivers, they are not so regular about monitoring the effluents produced by industries. Also, even if several polluting industries meet CPCB statutory requirements, ambient water quality can deteriorate if there are a number of such industries in a locality. Polluting industries are usually willing to make a one-time investment and set up effluent treatment plants, especially if the investment involved is small. But as operating costs can be high they are often reluctant to run these plants. After an initial verification that pollution control devices have in fact been installed by the industry, the Central and State pollution control boards are not equipped to check on their regular operation, allowing the offenders to get away. The present pollution control policy doesn't address small-scale industries, which pollute with impunity. Setting up functioning common effluent treatment plants, through appropriate incentives are important. Small-scale industries may have to be relocated together to facilitate the establishment of such facilities.

Although elaborate provisions of the law appear to exist, the law remains ineffective and the environment continues to deteriorate. Experts from the National Law School of India University, Bangalore have evaluated the existing pollution control laws and suggested several reforms. They suggest that the principal legislation is repetitious and poorly drafted. The laws are not backed by sound policy pronouncements and the legislation does not appear well thought out but seem ad hoc. The pollution control laws are based on a command and control regime with an emphasis on punitive rather than pro-active and preventive measures. Though the boards have wide ranging powers, including the ability to hold industrialists personally liable for environment damage these are rarely exercised effectively. Undue emphasis is placed on criminal procedure, and as a result there is considerable delay in convictions.

Before judicial process is initiated against polluters, spaces for cooperation and partnerships between various groups should be explored. Central and State Boards also need powers to impose progressive monetary penalties on the polluters. This will, to a great extent, reduce need for time consuming legal recourse. Greater cooperation between central and state pollution control boards is needed. Conflicts over jurisdiction between the state boards and the district administration should also be resolved for effective implementation of legal provisions.

Key words: enactment; pollution; water

WATER QUALITY DETERIORATION OF RIVER YAMUNA FEEDING TO DELHI, INDIA

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Yamuna River feeding to about 28 % inhabitants or 3 million people of Delhi city has suffered severe pollution since 2003, resulting acute difficulties to treatment plants in Delhi to make it fit for drinking purpose. Sixteen times information was given in written to concerned authorities like CPCB, HPCB & HID by the Director (Treatment & quality Control) of Delhi Jal Board. Moreover, water supply pumping to citizen of Delhi had been affected five times during pollution in river Yamuna since 2003 to 2007. Pollution reached its extremities on 13-11-2007 evening when hazardous ammonia pollutants exceeded its limit of treatment and water treatment plants remained non-functional for more than 24 hours leaving Delhi's population thirsting for water.

Key words: Water; River; Pollution; Government

FOLK UTILIZATION OF SOME NON-TIMBER FOREST PRODUCTS BY THE TRIBAL COMMUNITIES IN AND AROUND DAMPA TIGER RESERVE OF MIZORAM IN N.E. INDIA

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The present study is an attempt to describe the anthropogenic approach towards the non-timber forest products of the hill tribes in and around Dampa Tiger Reserve of Mizoram and seeks to investigate the plants used for several purposes by the hill communities in their quotation critics, to record the plant species of medicinal value, wild edibles, fibre yields, insecticides and pesticides, to identify the taxa used in religious ceremonies and psychological practices of the local people and document the species used as vegetable, fruits, seeds grains species and condiments oils and beverages as wild edible of the state. The paper is based on extensive ethno-botanical surveys substantiated further by data collected through pre-structured questionnaires made during 2005-2007 and with the help of literature screening on the previous works. Our results revealed that excessive collection of the high-volume, low value NTFPs, such as fuel wood, fodder, and mulch around the reserve, has brought more forest degradation and hardships for households while the collection of relatively high-value, low-volume NTFPs, such as specialty food products, inputs to local cosmetics and crafts, and medicinal plants, has increased living standard of the poor around the Dampa Tiger Reserve.

Key words: Folk; NTFPs; Mizoram, Hill tribes, Dampa Tiger Reserve

CONSERVATION AND MANAGEMENT OF FEW ECONOMICALLY IMPORTANT PLANT SPECIES OF ARUNACHAL HIMALAYA

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Anthropogenic activities are causing extinction of many species of ecological and economic importance. Arunachal Pradesh, house of biodiversity and endemism, many more species facing tremendous pressures and extinction. This paper focuses on conservation and management of few aromatic, medicinal, ethnobotanical and economic important plant species viz., *Coptis teeta*, *Gymnocladus assamica*, *Illicium griffithii*, *Rhododendron* spp. and *Taxus wallichiana* which are under threat.

***Coptis teeta*:** Rhizome having protoberberine alkaloids of berberine, palmatine, coptisine, etc., and an aporphinoid alkaloid of magnoflorine used for dispelling heat, drying dampness, removing toxins and purging fever. Growing demand has resulted over harvesting and risk of extinction.

***Gymnocladus assamica*:** Pods are highly saponaceous used as an alternative for soap. Excess harvesting of fruits and consumption of pods by wild pigs, deer, cattle leads depletion and verge of extinction.

***Illicium griffithii*:** Pods used for carminative and aromatic stimulant (<http://www.frlht.org.in>). Because of high demand people harvest fruits either before mature or when seeds are still within fruits and for fuel wood have hinders regeneration and depletion of habitat.

***Rhododendron* spp.:** Flowers have anti-tumour, anti-inflammatory and anti-ulcer properties. Leaves used for incense, aromatic, hemicranias, rheumatism, syphilis, anti-HIV, narcotic and insecticide purposes. Current deforestation may lead extinction of some species.

***Taxus wallichiana*:** Endangered, economic tree species having anti-cancerous chemical paclitaxel besides other important medicinal uses in Unani, Ayurveda and Tibetan Medicine.

Conservation and management : Extinction can be minimized through proper conservation responses, in depth research, species specific actions, site and habitat based interventions, policy making, communication and education. Restoration of habitats through protected area networks either *in-situ* or *ex-situ*.

Key words: Himalaya; natural resource management; conservation.

AN ANALYSIS OF THE IMPACT OF CLIMATE CHANGE ON RESOURCE BASED LIVELIHOODS IN UTTARAKHAND

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To facilitate the development of a strategy to minimize the adverse effects of climate change, it is first necessary to determine the effects of climate change that have the most impact on the communities and their livelihoods. This paper presents the results of a participatory survey in two valleys in Uttarakhand in 2009. Information was obtained on a wide variety of topics including perceived weather changes, cropping patterns, crop productivity, pastoralism, changes in forest ecosystems, and availability of non timber forest

produce. These surveys have yielded important evidence of the various changes happening in the valleys, the proportion of these that could be directly linked to climate change, and their effect on rural livelihoods. This information has the potential to direct intervention strategies and funding where it can have the most efficient and sustainable impact.

Key words: baseline; Himalayas; resource-based livelihoods; adaptive management.

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BIODIVERSITY CONSERVATION, CLIMATE CHANGE AND ECOSYSTEM SERVICES IN MOUNTAIN ECOSYSTEMS

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Climate Change is widely acknowledged to be having a profound impact on global resources as the mountain ecosystems (directly or indirectly) which are highly sensitive to climate change. Because of the variation of climatic regimes along an elevational gradient, biodiversity in mountains commonly exceeds that in the lowlands and forms several typologies of landuses. These fulfill various human needs, as well as act as a host of other ecosystem services such as snow-based recreation, timber, unique flora and fauna, and critical habitat for rare and endangered species. Climate change also poses special problems for mountainous protected areas because of the unique site specificity at higher elevations.

The challenge with us is to sustainably manage the biodiversity especially of mountainous areas keeping in mind the conservation, use pattern and sustainable supply of resources. Several multifaceted measures are required to be understood in this context. The role of climate change and ecosystem services for sustainable utilization of mountain biodiversity is very important and calls for valuation of ecosystem services, which ultimately reflect the importance of biodiversity conservation. This requires discussion on issues like land utilization pattern, assisted regeneration potential, afforestation, environmental conservation measures, sustainable harvest limit of resources, indigenous management practices etc. The paper will discuss these issues with an ecosystem approach for better management of mountainous resources for sustainable supply.

Key words: Climate Change; biodiversity; mountainous ecosystems

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BIODIVERSITY CONSERVATION AND SUSTAINABLE MANAGEMENT OF FEW CRITICALLY ENDANGERED MEDICINAL PLANTS IN THE NATURAL FORESTS OF CENTRAL INDIA

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Due to over-exploitation of many medicinally important species, few herbaceous species falls under critically endangered or vulnerable category. Currently medicinal plants are collected without paying attention to the stage of maturity. *Cissus quadrangularis* is an indigenous medicinal plant of India. The use of this plant by the common folk for promoting fracture healing process is an age old practice. Since then it has been in extensive use by bone setters both for external application as well as internal medicine. Over-exploitation of *Tylophora asthamatica* like other herbaceous species has made them endangered species in the natural forests of central India. This species is recently adopted as one of the important drugs from

natural source for the treatment of respiratory diseases. The study was conducted in the central part of Madhya Pradesh, which is rich in the herbaceous medicinal plants. Few districts of central India have been selected for the present study. The ecological status, plant density, regeneration and current harvesting practices adopted by the primary collectors and its impact on biodiversity were assessed in this paper. The paper also discusses the sustainable management of few selected medicinal plants under wild conditions.

Key words: Endangered, Over exploitation, Medicinal plant, Harvesting, Herbs.

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LONGITUDINAL DISTRIBUTION OF BENTHIC MACROINVERTEBRATE COMMUNITY IN THE CENTRAL HIGHLAND RIVER, KEN, INDIA

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Factors governing the longitudinal distribution of benthic macroinvertebrate community in the Vindhyan river Ken was studied. It is a 340 km. long left side tributary of the Yamuna draining the northern slopes of the Vindhyan hills between 23°59' N to 25°46'54" N latitude, 80°15'45" E to 80°32'08" E longitude 92100 to 365 m asl altitude in the Peninsular India. The samples from headwater (S1) to mouth (S4) collected by lifting of stones, sieving of silt-clay substratum (20 quadrates, 1ft²) and preserved in 4% formalin for the further analysis. Density (indiv. m⁻²), percentage composition was assessed and cluster analysis was performed to determine the similarity within the sampling stations. The ordination techniques i.e. principal component analysis (PCA) and canonical correspondence analysis (CCA) were applied for characterisation of the stations and determining the environmental factors governing longitudinal variation, respectively. The mean density decreased longitudinally from S1 (319 ± 24.23) to S4 (248.6 ± 27.5). Kruskal-Wallis test ($t_{0.05}=7.81$, $H=17.05$) showed significant differences in the mean density among all the stations. The community comprised insects, molluscs and annelids. The share of insect was very high in the whole community from S1 to S3 (84 - 91%), except S4 (49%). Mollusc share varied from 2% to 32%, while lowest at S2 and S3. Annelids were present only at S1 (5%), S2 (4%) and S4 (20%). The assemblages varied longitudinally; Ephemeroptera (70-1%) decreased from S1 to S4, while Diptera increased from S1 (11%) to S4 (31%). Trichoptera was absent at S4 and increased from S1 (3%) to S3 (25%). Longitudinally, PCA showed that Caenidae, Neophemeridae, Leptophlebiidae and Thiaridae were characteristic taxa at the station S1, S2, S3 and S4, respectively along the river. CCA indicated that taxonomic composition was influenced longitudinally by abiotic substratum (stony, silty, sandy, clay) from S1 to S4, while biotic substratum (aquatic vegetation) influenced the taxonomic composition at S2. Substratum became an important factor longitudinally because its size exhibited heterogeneity and was not affected by the landuse as it was a topographic feature. Landuse emerged as important factor for the river as a unit, because landuse type varied from S1 to S4.

Key words: River continuum concept, Community composition, environmental variables.

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FAUNAL DIVERSITY OF CHANDAKA-DAMPARA WILD LIFE SANCTUARY WITH SPECIAL REFERENCE TO ASIAN ELEPHANTS

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Chandaka-Dampara wild life sanctuary, located adjacent to the capital city of Bhubaneswar, Orissa represents the North eastern limits of the Eastern ghats. After the declaration of the forest as wild life sanctuary in 1982, steps have been initiated for the over all protection of the gasping forest ecosystem and more precisely to provide a congenial habitat to the resident Asian elephants. The flora in this sanctuary is moderately diverse with intimate mixture of evergreen and deciduous elements. Elephant is the flagship animal species and the sustenance and development of the forest is hinged with this animal. Hanuman langur, the macaque, spotted, barking and mouse deers, wild pig, sloth bear, leopard, hyena, wolf, fox, jackal, mongoose and pangolin are the other mammals spotted in the sanctuary. Reptilian and avian fauna show a wide diversity. Reptilian fauna include Bengal monitor, mud turtle, chameleon, python, cobra, Russels viper, pit viper, rat snake, earth boa etc Avi fauna are largely water fowl, and wader, raptor, ground nesting birds and song birds .Threats to wild life are mostly due to unplanned tourism, establishment of projects in the ecosensitive zones, cattle grazing and heavily populated habitations close to the sanctuary. Conservation plan aims at habitat protection, improvement and consolidation.

Key words: Wild life sanctuary, elephant, faunal diversity

1019

FLORISTIC COMPOSITION OF THE EPILITHIC DIATOMS CENTRAL HIGHLAND REGION OF INDIAN SUBCONTINENT

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The taxonomical diversity, or species richness, is used to describe the former and recent state of aquatic biota in these river systems. The ecological diversity, obtained by incorporating the concept of ecological groups into the concept of biodiversity, appears very useful in delineating guidelines for ecological river management. A study was designed to assess and understand the diversity patterns (species richness, diversity and evenness) of freshwater lotic diatoms in the tributary of Ganga-Yamuna River System (Ken, Paisuni, Tons) India. Thirty three epilithic samples were obtained by scraping an area of 3x3 cm. from cobbles at the 11 sampling stations (Ken, Tons, Paisuni) situated between latitude 23°30' to 26° N and longitude 78°30' to 82° 30' E. The taxonomic richness in the River Ken, Tons and Paisuni was 205, 202, and 211

Key words: central highland; diatom; diversity

1020

CLIMATE CHANGE AND ITS IMPACT ON FOREST AND DEPENDENT LOCAL COMMUNITIES: A CASE OF BAIGA TRIBES OF CENTRAL INDIA

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Forests are the frontline in mitigating climate impacts by reducing exposures to scouring heat, dust storms and floods. Fluctuating weather conditions in India suggest that the country is reeling under climatic chaos. For more than a decade now, the country has been experiencing contrasting extreme weather conditions: from heat waves to cyclones, from droughts to floods. Orissa, Bihar for instance are states of a classic example of climate change events. Several indigenous communities make their living within vulnerable environments- in mountainous areas, in forests or in dry areas and often the first to discern and suffer the effects of climate change. These peoples are not just victims of global warming; they have a critical role to play in supporting global adaptation to climate change.

Tribes of Dindori district acquire a distinctive knowledge of plant genetic diversity needed to fight plant and animal diseases and their know how to breed varieties that can cope with stressed environments. Local communities have always aimed to adopt variations in their climate. The Tribal peoples living in and around world famous Kanha national park posses knowledge about wild varieties of Agricultural crops (particularly Rice and Wheat) and other edible food crops. They are still growing various Agri-crops using organic manure since time immemorial. They are still growing Kodo and Kutki (rice) varieties besides its very low yield. They are utilizing wild tubers (yams) efficiently in the harsh conditions. Local indigenous knowledge to cope up adverse climatic conditions was documented and discussed in the paper.

Key words: Indigenous, Tribal, Climate Change, Communities, Forest.

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RESTORATION OF WATER QUALITY AND BIO-DIVERSITY OF A RAMSAR WETLAND THROUGH IMPLEMENTATION OF CONSERVATION MEASURES – A CASE STUDY

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Bhoj wetland of Bhopal, one the important Ramsar sites in Central India was one of the victims of rapid urbanization. The wetland popularly known as Upper Lake was constructed in the 11th century by constructing an earthen dam (Kamla Park) on the river Kolans near Retghat by king Bhoj of the Parmar dynasty. The wetland was constructed to cater the needs of potable water. At present the wetland is also used for unorganized irrigation, fish culture, and other secondary purposes. Besides its multipurpose use, the wetland is an important site of bio-diversity especially for migratory and residential birds inhabiting more than 175 species of migratory and residential birds, 100 species of macrophytes, 200 species of phytoplankton, 100 species of zooplankton, 40 species of fish fauna, 90 species of insects and 10 species of reptiles and amphibian.

However due to tremendous population growth of the Bhopal city (about 70,000 in 1951 to about 13 lakhs in 2001) and rapid urban development around on the eastern and northern fringes of the wetland, especially during 2nd half of the last century the water body had been subjected to various environmental problems resulting in deterioration of their water quality and reduction in bio-diversity.

Thus for improvement of the water quality as well as to restore the biodiversity of the wetland, an integrated conservation & management programme (Bhoj Wetland Project) having both preventive and curative measures was implemented during the year 1995-2004. The action plan was implemented through 19 subproject action programme. Some of the important measures implemented for conservation and management of the wetland included the followings:

- Creation of buffer zones between the Lake and the human settlements through afforestation
- Catchment Area Treatment
- Interception and diversion of Sewage
- Improvement of solid waste management system
- Removal of nutrient enriched silt through de-siltation
- Increasing flushing rate through deepening and widening of the Spill Channel:
- Control of Idol Immersion activities to prevent addition of solid wastes and toxic substances
- Removal of excessive Weeds
- Installation of Lake water oxygenation systems
- Promotion of Aquaculture
- Water Quality Monitoring
- Public Awareness Campaign

Impact of Implemented Action

- i) Improvement in water quality – due to stoppage of dumping of solid waste and idol immersion activities, installation of ozonizer and fountains, de-silting and weed removal, improvement in water quality in general has been observed after completion of the Bhoj wetland project.
- ii) Improvement of bio-diversity due to massive plantation. About 17 lakhs plants have been planted in over 1000 hectare land for over a period of 12 years. In the programme under social forestry, about 2.06 lakhs of plants have been distributed to the farmers and were planted in the catchment area.
- iii) The improvement of habitat condition of Upper Lake - Due to de-silting & weed removal, population of migratory birds has increased. Congregation of *Grus antigone*, a vulnerable species, which is of international importance was also noticed.
- iv) Improvement of socio-economic conditions of fishermen due to increase in fish production from 59 tons/annum to 136 tons/annum over a period of 3 years through planned aquaculture.
- v) Reduction in siltation due to construction of catchment area treatment and creation of buffer zone plantation.
- vi) The project implementation has provided many job opportunities for the local people.

Key words: Bhoj Wetland, Water Quality Deterioration, Bio-diversity, conservation measures

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IMPACT OF CLIMATE CHANGES ON THE SOIL FAUNA

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The global warming is one of the most alarming problems of the 20th century. Its importance has been recognized globally natural/ human induced increase in mean global temperature of earth surface has been established phenomenon. The green house gases (CO₂ water vapor, N₂O, synthetic CFC's and CH₄) trap heat and light from the sun in the earth's atmosphere. It plays a vital role in determining the earth's average temperature which leads to hazardous climate events.

The rise in temperature near the surface of the earth, ocean or mountains above the acceptable limit is called global warming that causes glaciers to melt, resulting rise in ocean water. Animals are just reacting to what's going on out there and if their behavior is very similar to what we expect with what's going on with Global warming. Due to climate change Species responded in following ways:

1. Species migration.
2. Shift in timing of natural events (flowering, migration, and egg-laying). Ecosystems are intricately connected webs, and even if a species does not rely on temperature and daylight cues to trigger certain behaviors, it may interact with other species that do.
3. Ecosystems and wildlife are not the only things that increasing temperatures will affect global warming is going to be a big stress to all animals, including human. Climate change affects almost all ecosystems, society and economy. But the effects are different depending on their locations, economic status, history of development and governance patterns.
4. Invertebrate fauna have great influences on the structure and performance of plant communities. Their influence may be direct through herbivory including occasional pest outbreaks or indirect through the influence of soil fauna on decomposition and other soil processes.

The responses of soil fauna to increased concentrations of atmospheric CO₂ and the consequent climate change will affect several attributes of animal populations and communities including their density, biomass, diversity, and activity, rates of consumption, life history parameters and migration ability.

Changes in the quality and quantity of litter and global warming are the main factors which are expected to modify soil fauna. Because of complexity of the biological mechanisms following consequences/responses have been reported under several factors;

(i) Changes in the food resources for soil fauna in the litter layer and in the rizosphere (ii) The consumption of low quality litter by the macro fauna (iii) The changes in life span in response to temperature elevation (iv) The enhancement of earthworm burrowing activity (v) The changes in community composition arising because of specific differential resistance to adverse conditions. There are several soft-bodied animals (enchytraeids and collembolans, including centipeds and millipedes) which are sensitive to desiccation during dry conditions. It indicates that altered moisture and temperature will have definite effects on soil fauna.

Key words: Climate change, soil fauna

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A PHYSICO-CHEMICAL ANALYSIS AND HEAVY METAL CONTENTS OF AGRICULTURAL SOIL AT SELECTED SITES OF FAIZABAD

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An investigation was carried out to study the Physico – chemical parameters and Heavy – metal contents in agricultural soil of National Thermal Power Corporation (NTPC), Tanda Ambedkar Nagar, Masaudha (MS) and Normal agricultural land (NAL) Faizabad. It has been observed that temperature was 20% more at NTPC followed by MS (10%) and NAL. The pH was recorded as 8% more at NTPC followed by MS (6%) and NAL. The moisture content of NTPC and MS was 51% and 47% less than NAL soil, respectively. The bulk density of MS and NTPC was 8% and 22% less than NAL, respectively. The EC value at NTPC and MS was 78% and 48% higher than NAL soil, respectively. The CEC concentration of MS and NTPC was 10% and 28% less than NAL, respectively. The concentration of nitrogen was 40% and 47% less at MS and NTPC than NAL soil, respectively. The Zn concentration was 18% and 29% less at NTPC and MS than NAL soil, respectively. The concentration of Fe was more at NTPC (49%) followed by MS (16%) and NAL. Mn concentration was high at NTPC (6%) followed by NAL and MS. NTPC soil has high values of Cu (37%) followed by MS (8%) and NAL, which indicate possible contamination. The presence of metals in soil must be thoroughly studied to assess the future prospects of crop production in India.

Key words: Physico-chemical characteristics, Heavy metal, Soils, Faizabad

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FAUNAL DIVERSITY ADJOINING TO THE CAVES OF BUDHAKHOLA IN BAISIPALLI SANCTUARY OF SOUTH ORISSA, INDIA

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Budhakhola (Lat 19°82' N, Long 84°82' E) is an important tourist destination of religious and cultural importance in Ganjam district of Orissa. Located near Buguda which is one of the entry points of Baisipalli sanctuary, Orissa, India. The study area is part of Deccan peninsula Bio-geographical zone, Eastern plateau province and Eastern Ghat sub-division. There are number of caves present inside the sanctuary. The cave near the Budhakhola is known as Budha Gumpha or Budha cave. The cave and surrounding area is habitat of a wide range of flora and fauna. The well wooded hilly terrain is an excellent habitat for elephant, bear, tiger, leopard, chousingha, barking deer, wild boar, python, king cobra and number of birds. The presence of giant squirrel an arboreal mammal and hornbill indicate a healthy forest

cover. Because of lack of roads, the interior of this area is still unexplored. Balipadar-Bhetnoi, a wildlife reserve present within the radius of 20 km is one of the best examples of success stories of conservation of wildlife, solely by local community. The present study aimed at gathering information about the faunal diversity present near and around Budha cave.

Key words: Biodiversity, Deccan peninsula Bio-geographical zone, Eastern Ghat, Budhakhola.

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DEPENDENCE OF FOREST DWELLERS ON THE NON-TIMBER FOREST PRODUCTS FOR LIVELIHOOD GENERATION AROUND DAMPA TIGER RESERVE IN NORTH-EAST INDIA

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In North-East India, over-extraction of fuelwood and other Non-timber forest products (NTFPs) for revenue generation has occurred at a faster rate in recent years. A detailed and systematic study about the NTFP resource base, probable impact of harvesting and collecting practice, NTFP inventories and dependence by the dwellers around protected forest areas of North-East India, however is lacking. A study was therefore undertaken around Dampa Tiger Reserve to assess the NTFPs resources, the extent of income generation using Participatory Rural Appraisal (PRA) for resource mapping, NTFP availability and extraction, and quadrat method for quantitative assessment of NTFP species. About 98% of households were found engaged in collection of a diverse variety of NTFPs. Broom stick, fuel wood, bamboo shoot, fruits and wild vegetables were among the notable NTFPs in the area which contributed significant income to the households. A total of 91 plants species belonging to 56 families and 68 genera contributed to NTFP diversity in the area of which 13 genera were found critically endangered, 44 wild edible fruit species belonging to 24 families were used extensively. We observed that many NTFP species are dwindling around the Reserve and therefore need sustainable management for market and non-market product outputs.

Key words: NTFP, Livelihoods, forest dependence

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STRUCTURAL DIVERSITY AND FUNCTIONAL DYNAMISM OF TRADITIONAL HOME GARDENS OF NORTH-EAST INDIA

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Forty five homegardens (size from 0.035ha to 2 ha) positioned in North-East India was studied in details for their structural and functional dynamism in relation to livelihood support. A total of 205 different plant species (92 herbs, 31 shrubs and 82 trees) belonging to 66 families and 161 genus were recorded. Thirty two families were represented only by a lone species while 18 families by more than five species. Shannon Weiner index for both trees and herbs were maximum in the large homegarden ($H' = 3.73$, $P < 0.005$) and minimum for shrubs in large homegardens. The households cited most species as useful for food (45%) followed by medicine (13%), fuel wood (12%), ornamental (9%) and timber (7%). The energy input ranged from 125 MJ per m² in small to 31 MJ per 100 m² in large gardens and monetary input significantly vary from Rs. 928 per 100 m² in small to Rs. 228 per 100 m² in large gardens ($P < 0.02$), however, no significant difference for the monetary output and the output-input ratio was observed between the gardens. The total energy output was 3728 MJ, 1365 MJ and 1452 MJ in the small, medium and large homegarden respectively.

Key words: Home gardens, NE India, diversity

DISTRIBUTION OF AIR POLLUTANTS IN DIFFERENT SITES AT AYODHYA AND FAIZABAD, U.P.

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Monthly analysis of Respirable Suspended Particulate Matter (RSPM), Suspended Particulate Matter (SPM), Sulphur Dioxide (SO₂) and Nitrogen Dioxide (NO_x) was studied at industrial, rural, and urban locations of Ayodhya and Faizabad. In this study, impact of RSPM, SPM, SO₂, NO_x on local plants was seen. The pollutants are reaching in the plants through stomata. The suspended particles deposited on the plant leaf surface and disturbed the physiological and biological processes. During survey of the different locations of Ayodhya and Faizabad I found that the crop plants was badly affected due to presence of air pollutants. The main source of air pollution in this area is vehicular exhaust emission and transportation .

Key words: RSPM, SPM, NO_x, SO₂ Impact, plants.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN CORE SEDIMENTS FROM SUNDARBAN MANGROVE WETLAND (INDIA) AND THEIR ECOTOXICOLOGICAL SIGNIFICANCE

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Polycyclic aromatic hydrocarbons (PAHs) are lipophilic, persistent organic contaminants (POPs) that are widespread in the environment. The present work elucidates the distribution and potential sources of 16 polycyclic aromatic hydrocarbons (PAHs) in sediment cores (<63 µm particle size) of the Indian Sundarban mangrove wetland, a UNESCO World Heritage Site, were investigated, by gas-chromatography coupled to mass spectrometry (GC-MS). The Indian Sundarban (21°31'6" to 22°12' 14" N and 88°11' 28" to 89°05'53" E) is a mangrove wetland belonging to the low-lying coastal zone, formed at the estuarine phase of the River Ganges. The wetland is characterized by a complex network of tidal creeks, which surround hundreds of tidal islands exposed to different elevations at high and low semi-diurnal tides. Reclamation of land, deforestation, industrial and agricultural wastes impart variable degree of anthropogenic stresses leading to concentrations of both heavy metals and POPs.

Four sampling sites have been chosen taking into consideration of the representative locales of the variable environmental and energy regimes of the wetland which covers a wide range of substrate behavior, wave-tide climate, intensity of bioturbation (animal-sediment interaction), geomorphic-hydrodynamic regimes and distances from the sea. Cores of 30 cm length were collected in the winter season (January-February) with the help of a steel corer (40 cm long and 5 cm diameter) by gently pushing it into the sediments and dug out, capped and frozen on return to the laboratory. The core length size differs between the stations due to variations in nature of the substratum. Each core was sliced into 4 cm fractions (sub sample) with the help of a PVC spatula. Sliced samples were then oven dried at 50°C and then gently disaggregated, sieved through 63 µm metallic sieves and individually transferred into pre-cleaned inert polypropylene bags and stored at -20 °C for subsequent extraction and chemical analyses. The sediment samples were characterized for particle size, pH and organic carbon. Significant differences among sampling sites were checked by main effects analysis of variance (ANOVA) using \sum 16PAHs as variables and stations and depth profiles as different factors. The data set was analysed with principal component analysis (PCA) which is often used as an explorative tool to extract components needed to explain variance of observed data. All statistical analyses were carried out by the software package STATISTICA 6.0.

Regarding sediment quality parameters, values of pH range from slightly acidic to basic (pH 6.5 to 8.4) where the acidic nature might be partly due to the oxidation of FeS₂ and FeS to SO₄²⁻ and partly results from the decomposition of mangrove litter and hydrolysis of tannin in mangrove plants releasing various kinds of organic acids. Low values of organic carbon are related to the poor absorbability of organics on negatively charged quartz grains, which predominate in the intertidal sediments of this estuarine environment. Regarding textural composition, the four stations also exhibit wide variations which may be attributed to vigorous estuarine mixing, suspension-resuspension and flocculation-deflocculation processes. These variations may influence the PAH accumulation in the core sediments where the processes involved are quite complex in nature.

The total concentrations of 16 PAHs (Σ_{16} PAHs) ranged from 132 to 2938 ng g⁻¹, with a mean of 634 ng g⁻¹, and the sum of 10 out of 16 priority PAHs (Σ_{10} PAH) varied from 123 to 2441 ng g⁻¹ with a mean of 555 ng g⁻¹, and the 5 carcinogenic PAHs (benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, benzo[*a*]pyrene, indeno[1,2,3-*cd*]pyrene and dibenz[*a,h*]anthracene) accounted for 68-73% of the priority PAHs. The prevalent erratic vertical distribution of PAHs might be mainly related to the non-homogenous textural composition of the different sediment core layers resultant from the particular hydrological conditions of the Ganges estuary and adjoining Sundarban wetland situated under a meso-macrotidal setting and seasonal flow rate fluctuations. Maximum concentrations of the sediment core were obtained at subsoil depth of 12-16 cm. The prevalence of 4-6 aromatic ring PAHs and cross plots of specific isomer ratios such as phenanthrene/anthracene, fluoranthene/pyrene and methylphenanthrenes/phenanthrene suggested the predominance of wood and coal combustion sources, the atmospheric deposition and surface runoff to be the major transport pathways. A good correlation existed between the benzo[*a*]pyrene level and the total PAH concentrations, making this compound a potential molecular marker for PAH pollution. Total toxic equivalency (TEQ_S^{carc}) values calculated for samples varied from 6.95 ng g⁻¹ TEQ_S^{carc} to 119 TEQ_S^{carc} with an average of 59 ng g⁻¹ dry wt TEQ_S^{carc}. Sediment quality values were used in the calculation of risk quotients included the Hong Kong Interim Sediment Quality Value (HK-ISQV) and Canadian Sediment Quality Guidelines (CSQG) as well as effects range low (ERL) and the effects range median (ERM) values.

Relative to other urbanized coastal areas worldwide, the prevalent PAH content of the Sundarban sediments can be considered low to moderately contaminated resulting from the impact of the rapid economic development of the surrounding regions for the last two decades. The PAH diagnostic ratios indicated that the PAHs in the sediment cores were mainly of pyrolytic origin mainly transported by surface runoffs. The data provide background information that should be useful in designing future strategies for environmental protection and management of the wetland, considering the industrial and agricultural growth around this coastal environment.

Key words: Mangroves, PHAS, management

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INTRASPECIFIC DIVERSITY IN FRESHWATER FISHES

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Intraspecific divergence reflected through morphology may or may not be of genetic in origin. The morphological changes as seen among or between individuals of the same species could be purely environmental, and hence may represent the phenotypic plasticity of the species. A few early studies have characterized stocks on the basis of quantitative genetic traits (phenotypic) indicating that differences are the products of environment and gene interactions. The molecular studies suggested higher intraspecific diversity in freshwater fishes than in marine and anadromous fishes because of presence of more physical barriers in land based water bodies. There have been some excellent reviews of the stock identification research and the conference proceedings containing case studies. In fact, there is a long history of studying the fish stocks through morphometric and meristic features globally, but there is nonetheless the paucity of studies on genetics of Indian fishes in general, intraspecific divergence in particular. However, the huge fishery resources with tremendous diversity of species distribution in India offer unmatched scope for genetic and evolutionary studies.

The development of molecular genetics techniques have made possible to understand the genetic constituents of fish, and revolutionized our ability to understand genetic divergence at subspecies level in freshwater fishes. Over the past 40 years several molecular genetic techniques based on protein allozymes, mitochondrial DNA and genomic DNA have been developed to examine the genetic variation within and between the groups of a species. However, the studies which can address whether the intraspecific divergence represented in morphology has the functional meaning have not been carried out.

In order to study the phenotypic manifestations of genetic diversity the samples are collected from the water bodies which are geographically distant and characterized by different environmental conditions as the fishes living in different place influenced by different climatic and environmental conditions.

The standard protocols include both traditional (Morphometric, meristic, natural markers such as otolith, tag and parasite) and new technologies (allozymes, molecular markers, and electronic tag) are used for stock analysis studies.

Key words: Biodiversity, freshwater systems

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COMMUNITY STRUCTURE AND SPECIES ABUNDANCE IN TRANSFORMATION OF HABITAT

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Habitat exerts a strong influence on the organization of plant communities. This hypothesis was tested at three sites of the Indo-gangetic plain where degraded sodic lands were developed and managed under cultivated systems for the five years. Plant community analysis was carried out in the uncultivated sodic land site (USL, control), semireclaimed crop field (SCF; 5 yr old) and a non-sodic crop field (NCF; reference site). Indicator species for the specific site were determined on the basis of their distribution in fidelity classes. *Sporobolous maderespatanus*, *Desmostachya bipinnata*, *Calotropis procera*, *Pulicaria crispa* and *Eragrostis tenella*, *Cyperus sps* and *Zyzyphus rugosa* were exclusively found in barren sodic land and were totally absent in semireclaimed as well as non-sodic soil sites. Some other species like *Cyperus triceps*, *Sporobolus diander*, *Dactyloctenium aegypticum* etc. were found selectively in sodic lands but occasionally occurred in semireclaimed soils. *Paspalum vaginatum* and few species of *Cyperus* were also found in such soils, although they were restricted to rainy season only. Forbs (70%) and grasses (19%) dominated the total weed community, whereas legumes (11%) were minor. It was observed that proportion of forbs in total weed spectrum increased from USL to SCF and NCF whereas, grass proportion reduced correspondingly. Percentage of legumes changed slightly from SCF (12%) to USL (9%) in descending order. Dominant families in the weed community were Poaceae with 52 species (19%), Asteraceae with 34 species (12%), Leguminosae with 30 species (11%), Cyperaceae with 22 species (8%), and Euphorbaceae with 15 species (5%). Rests of the species belong to other 47 families in minor proportions. Some mathematical expressions indicate species-site relationships in the community, like, Shannon Wiener's index, species richness index, evenness or equitability, and heterogeneity, which increased from USL to NCF; whereas, the concentration of dominance decreased correspondingly. These indices may respond differently to geographical distribution, climatic and edaphic factors and can be used to compare one community with another. It was observed that different sites and habitats accommodate a wide range of characteristic species which are also influenced by seasonal fluctuations indicating relatively high species abundance in rainy season.

Key words: sodic soil; plant community; indicator species; endemic species

REHABILITATION OF BARREN SODIC LANDS UNDER AGRO-ECOSYSTEMS IN GANGETIC PLAINS OF NORTH INDIA

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Barren sodic soils of Indo-Gangetic plains are being reclaimed and cropped for raising the food production through World Bank assistance. Soil treated with gypsum (CaSO_4) following to submergence of field with water for about two weeks to make effective leaching of toxic sodium carbonate in surface soil enables cropping of rice-wheat. In this process many original plant species are replaced and recruited by crop associated weed community in due course of time. Their abundance and interactions with crop response as well as soil properties were observed for about five years to study the soil reclamation process on the three identified sites of variable climatic conditions. Several diversity parameters viz. species richness, population abundance, Shannon Wiener index increased significantly from uncultivated sodic land (USL, control) to semi-reclaimed crop fields (SCF), however, these increases were far behind to the level of non sodic crop field (SCF) -a reference site. Rainy season accommodates maximum species richness in all the habitats. Species dominance was concentrated among the few species in control site and tended to disperse among the many species in SCF and NCF sites. The yield of rice and wheat crops attained their maximum level in second year after that declined and maintained a constant level in subsequent years. Soil properties of the three distinct habitats (micro relief) exerted its influence on the organization of plant communities and crop yield. Soil properties (WHC, BD, porosity, pH, EC, ESP, and CEC) and nutrient concentrations (N, P, K, Ca, Mg, Na) varied greatly from USL to SCF and NCF. Micronutrients Cu^{+2} , Mn^{+2} , and Fe^{+2} showed higher values in NCF in comparison to USL and SCF sites, whereas addition of zinc sulphate in reclaiming fields to accomplish its deficiency has led to a relatively high concentration of Zn^{+2} in SCF as compared to barren and reference sites. Microbial biomass carbon (35.87 to 280.5 mg kg^{-1}), nitrogen (4.9 to 34 mg kg^{-1}), and phosphorus (4.13 to 12.27 mg kg^{-1}) increased from sodic to non-sodic crop fields. Similarly population of fungi and bacteria increased in semireclaimed and non-sodic crop fields but actinomycetes decreased correspondingly.

Key words: Uncultivated sodic land (USL), Semireclaimed crop field (SCF), Non-sodic crop field (NCF), β -diversity, microbial biomass

BIODIVERSITY ASSESSMENT AND PREDICTING SPECIES REDISTRIBUTION IN CLIMATE CHANGE SCENARIO

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The paper discusses about the key issues involved in conventional and new methods of biodiversity assessment, and the potential of new datasets for predicting redistribution range considering modeling and geoinformatics approaches for biodiversity conservation in the light of climate change. One of the major challenges faced by managers, policy makers, environmentalists, scientist or other stakeholders is the access to scientific databases, or information based on such databases. Another major challenge faced by most of scientific community is the non-availability of current, correct, complete and compatible geocoded information; this is particularly worrisome where so many government and non-government agencies are involved in duplication of the work/efforts. A well coordinated effort in conjunction with the latest technologies and modeling approaches viz., Remote Sensing, GIS, GPS, Ecological Models, Niche models, Bioclimatic Envelop models, etc. have made it possible to collect and represent data more precisely for decision making process. Since climate exerts maximum pressure on species distribution, but the role of

human interference, disturbance regimes, forest fragmentation levels, topographic variability etc. is equally significant. The joint efforts of Department of Biotechnology and Department of Space have generated primary data in last 13 years based on more than 20000 georeferenced sample plots across the country representing almost all ecosystems. Since anthropogenic pressures alter the matrix of the Earth's ecosystems through fragmentation, the vegetation cover type maps generated in this study have found use in quantification of fragmentation and disturbance regimes etc. Presently this geolocational species database has been used for quantification of biodiversity in terms of frequency, abundance and dominance of tree, shrub and herbaceous species. The bench mark data generated in this study has been used for characterizing biodiversity for conservation prioritization, gap analysis, extension PA network, gene pool location of medicinal and economic plants for bioprospecting, etc. It has demonstrated its potential in species in Niche modeling for new distribution locations of endangered and/or endemic species. The greatest threat due to climate change will be to endemic and rare species as their rate of migration may not match to the rate of climate change due to limited seed dispersal mechanisms and dynamics, hence these will not be able to migrate towards poles or higher altitudes nor regenerate and/or evolve *in situ*. The impact of climate change will be more pronounced on the tropical biodiversity found in most part of the country. The increase in temperature may lead to the shifting or alternation of boundaries of present distribution of biomes in India. The tropical forest/ecosystems will be worst affected.

Therefore, there is a need to make joint effort to create climate change scenarios on potential redistribution range of Indian biodiversity using appropriate scale and predictive models, Niche modeling, Dynamic Vegetation models, etc. It should be possible to integrate, share or exchange data in real time generated in biodiversity characterization project through web-enabled GIS. Thus there is need for multidisciplinary approach; and it would perhaps need to integrate additional information on seed dispersal, climatic data, soils, topography, hydrology, socio-economic data.

Key words: Biodiversity, climate change, species distribution

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ROLE OF AGROFORESTRY SYSTEMS IN CLIMATE CHANGE MITIGATION AND SUSTAINABLE LIVELIHOOD

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Currently one of the most pressing and globally recognized challenges we face is how to mitigate the effects of global environment change brought about by increasing emissions of greenhouse gases, especially CO₂. A number of strategies have been proposed to deal with this problem. Due to rapid urbanization, industrial pollution, deforestation and the large carbon based energy utilization; the process is again aggravated. Climate change is likely to impact all the natural ecosystems as well as socio-economic sections. Biomass plantations in surplus and wastelands deliver several spillover benefits like income for forest dependent communities, employment to surplus agriculture labour and land conservation, besides enhancing adaptive capacity of local communities. Properly designed mitigation and adaptation actions can advance sustainable development and equity both within and across countries and between generations. Carbon sequestration is characterized as an increase in carbon stocks on the earth through activities such as afforestation, reforestation, agroforestry, forest restoration, etc. The IPCC asserts that agroforestry has the potential to remove 50 billion tons of carbon dioxide from the atmosphere, which is equivalent to replacing 1,400 large coal-fired power plants with gas-fired facilities. Meanwhile, ICRAF (World Agroforestry Centre) asserts that allowing farmers to sell that carbon on global carbon markets could generate as much as \$10 billion each year for poor people in rural areas. Agroforestry systems have the potential to sequester atmospheric carbon in trees and soil while maintaining sustainable productivity. Trees are considered as carbon sink due to long period of carbon stay in the wood and addition of soil organic carbon. Carbon stocks in soil organic matter are one of the world's major carbon pools. Use of appropriate management strategies to increase the stock of carbon in tree biomass and in the soils thus implies a greater sequestration of carbon in addition to supply of long-lived forest products.

In India, Uttarakhand is a unique state with rich and biodiverse forest cover because of its topography, climatic conditions and close relationship between the religious and socio-cultural beliefs. Keeping above points in view, a study was undertaken in different agroforestry systems at GBPUA&T, Pantnagar (Uttarakhand). The proposed paper will analyse the various roles of agroforestry systems as a mitigatory measure for climate change, biodiversity conservation in order to face various environmental challenges for sustained livelihood.

Key words: Agroforestry; carbon sequestration; sustainable livelihood

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SOIL CARBON SEQUESTRATION AND CLIMATE CHANGE MITIGATION THROUGH AGRI-CHAR AMENDMENTS TO SOIL

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Agri-char is the carbon-rich product that remains when biomass is heated to high temperature in reduced oxygen conditions. Rather than being burned and oxidised to carbon dioxide gas as would happen in combustion or incineration in air, a proportion of the carbon in the biomass is retained within a solid residue. The biomass that is treated to create biochar can be grown biomass, for example wood, or it can be biowaste (agricultural residue) of various kinds.

In developing countries such as India, the agro-based industries such as rice mill and paper and pulp mill produce agri-char or biochar as solid waste which is rich source of carbon. This can be used for soil amendments. Hence, application of biochar to soils is an effective way of sequestering large amounts of C and may have other greenhouse gas reduction benefits such as reducing emission of N₂O and CH₄ from soils.

The soil amendments of agri-char is being carried out as a research work in Department of Environmental Science G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India. The study is being carried out in agricultural fields under different agro-ecosystems. The success of this research may result in enhanced soil carbon sequestration, clean solid waste management and green house gas emission reduction. This effort from lab to pilot scale may also help the country earn carbon credits through carbon capture and storage process.

In this report we examine the very recent interest in biochar, its sequestration in soils and the impact this might have on soil quality and productivity, from the perspective of innovative renewable energy technology, and current understanding of soil-plant ecology in order to assess where understanding is lacking and how the region and its economy might benefit from investment in biochar processes. Significant changes in soil quality including increases in pH, organic carbon, and exchangeable cations were observed at higher rates of biochar application (>50 t/ha).

Key words: Biochar, Carbon Sequestration, Agriculture, Greenhouse Gas Emissions

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ASSESSMENT OF AIR POLLUTION AT AROUND AYODHYA- FAIZABAD CITY, U.P.

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Air pollution levels are increasing at an alarming rate in many developing countries including India and causing a potential threat to plants and human beings. The problem of urban air pollution has attracted special attention in India due to a tremendous increase in the urban population; motor vehicle Vis a Vis the extent of energy utilization. Monthly analysis of air pollutants such as SPM, RSPM, SO_x and NO_x was studied at industrial, traffic, residential and sensitive locations of Ayodhya- Faizabad. The average upper and lower limits of air pollutants at different sites were observed for SPM (376-491µg/m³), RSPM (163-231µg/m³), SO₂ (12-29µg/m³) and NO₂ (31-57µg/m³) respectively. As a result of this, the gaseous pollutants SO₂, NO_x and aerodynamic size of respirable dust particle and suspended particulate matter pollutants were continuously assessed at residential and traffic intersection sampling stations in Ayodhya-Faizabad city. Impact of these pollutants would be discussed.

Key words: NO_x , SO_x , SPM and RSPM

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FISH BIODIVERSITY IN THE RIVER CHENAB DRAINING JAMMU REGION OF JAMMU AND KASHMIR STATE.

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The river Chenab, draining Jammu region, is formed by the confluence of two perennial streams viz Chandra and Bhaga at Tandi in Himachal Pradesh. It enters the state near Pador and after passing through Kishtwar, Doda, Reasi, Akhnoor ultimately enters Pakistan downstream Pargwal. Flow of this Coldwater River is very fast upstream Akhnoor. In Pargwal area, this is widespread of water forming a wetland. It is fed by a large number of warm water streams and spring fed pools, supporting a good fish fauna, below Akhnoor. Upstream Akhnoor, the river is joined by a large number of cold water torrential perennial and seasonal streams. Accordingly, a wide habitat is provided to the fish along the length of the river. An extensive survey of the river Chenab, during the last three years, has revealed the presence of sixty eight fish species belonging to six orders, twelve families and forty three genera. Perennial fish, catch like other Himalayan rivers, is contributed mainly *Schizothorax richardsanii*, *schizothoraichthyes progastus*, *S.esocinus* and *S. curvifrons*. Some of these fishes weighing more than 4 kg have been noticed in this river. Presence of seven species of *Glyptothorax* (*G.telechitta*, *G.garhwali*; *G.stoliczkae* and *G. aansii*, and one species of *Glyptosternum* is a unique feature of this Himalayan Indian river. *Glyptothorax* maximum diversity and density is seen during monsoon. *Tor tor* and *Tor putitora* are seen in large number during summer and monsoon seasons and migrate upstream from Pakistan for breeding in freshwater streams of Jammu.. Fishing methods commonly employed include Cast net, Pahai, Long line, Rod and Hook, Spear and torch, Gunny bags, poisoning, dynamite and grenade. There is a rapid decline in fish diversity and overall fish density in the river and is caused by (i) rise in number of fishermen (ii) small mesh sized fishing nets (iii) Poisoning methods of fishing (iv) Construction of reservoirs across the river.

Key words: Biodiversity, fish

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FLORISTIC PATTERN AND COMMUNITY DISTRIBUTION IN AN ALPINE MEADOW OF GARHWAL HIMALAYA

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Due to the prevailing severe climatic conditions alpine zones do not favor the growth of woody vegetation and herbaceous vegetation dominates the area. The present study area Dayara alpine pasture is located in district Uttarkashi of Uttarakhand lies between 30° 50.070' and 30° 49.383'N latitude and 78° 34.131' E and

78° 32.526' E longitude at an elevation ranging between 3345 and 3806 m. The study focuses on the plant diversity and community distribution in the area. The meadow serves as a home to many plant species of high resource value and to cattle of transhumance and localites. A total of 262 species of vascular plants belonging to 51 families and 155 genera were collected and recorded from the study area. Asteraceae and Poaceae were found to be the dominant families. Growth form spectrum reveals the dominance of short forbs in the area life form distribution pattern shows that chaemophytes dominate the area. Species richness in thirteen plant communities varied from 0.924 to 10.369 and diversity value ranged between 1.511 and 3.822. Evenness did not showed much variation whereas, concentration of dominance varied between 0.035 and 0.799. Highest similarity was recorded for *Iris hookerianum*- *Geum elatum* and *Bergenia stracheyi* community with 73.39 %.

Key words: alpine meadow, community, treeline, plant diversity, transhumance

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ECOLOGICAL RESTORATION AND BIODIVERSITY CONSERVATION

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Biodiversity is necessary to sustain the structure and key processes of the ecosystems, which control ecosystem services. The ecosystem goods and services that biodiversity provides are considered to be fundamental to healthy ecological and economic systems. Globally, only 1.9 million species have been identified taxonomically, though the estimated number of species could range from 5 to 100 million. The over exploitation of land and aquatic ecosystems by humans has resulted in the loss of biological diversity. About 60% of the ecosystem services have become degraded globally, mostly in the last 50 years, because of land- and ocean-use practices. In the year 2010, nearly two-thirds of the earth's ecosystems are considered degraded as a result of damage, mismanagement and a failure to invest and reinvest in their productivity, health and sustainability. The loss of biodiversity has implications for proper functioning of the ecosystems and livelihood of local people dependent upon biological resources. Climate change and climate variability will further alter the supply of ecosystem services that are vital for human well-being.

Ecological restoration is a powerful tool in facilitating the inherent recovery of ecosystem integrity in terms of biodiversity characteristics and ecosystem processes. The IUCN Commission on Ecosystem Management (CEM) has adopted ecosystem approach for promoting ecosystem restoration for sustainable development. A systematic meta-analysis of 89 restoration assessments has shown that restoration actions in a wide range of ecosystem types are effective in improving ecosystem services, particularly in the tropical regions. Thus, rehabilitation of degraded ecosystems combined with provision of financial incentives, such as payment for ecosystem services, REDD plus, and cost-benefit analyses can lead to high biodiversity conservation, livelihood benefits, and long-term carbon sequestration. There is need to improve techniques for monitoring of biodiversity and ecosystem services for various restoration actions.

There is insufficient information on the trends in most biodiversity components at the level of genes, species and ecosystems, ranging from the local to global scales. For the conservation of the species and maintaining ecosystem health, there is need for a concerted effort by taxonomists, ecologists and conservation biologists for exploring biodiversity over large areas. Improving the linkages between science and policy issues can be instrumental for more scientific decision making. The ecosystem services approach can save many ecosystems with high biodiversity and willingness of society to protect their biodiversity. The integrated ecological restoration and biological conservation within a unified ecosystem approach need to be developed. The implications of global climate change for restoration of ecosystems and conservation of biodiversity are priority areas of research.

Key words: Biodiversity, ecorestoration, ecological management

SPATIAL DISTRIBUTION OF FOREST BIOMASS USING REGRESSION MODELS AND REMOTE SENSING IN NORTHERN HARYANA, INDIA

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This aim of this study is to use spectral responses of MODIS satellite data, and forest plot biomass for developing an empirical model for aboveground biomass estimation in forests of northern Haryana. Spectral modeling of aboveground biomass was done on the basis of field data collected from 92 cluster plots of 0.1 ha across different forest types and forest densities in two districts of northern Haryana. A regression model was developed between reflectance value of red band of MODIS (SR) satellite data and above ground forest biomass. The total AGB was 26.99Tg and total carbon is 12.96Tg in an area of 593 km² in two districts of northern Haryana.

Key words: Aboveground biomass, Spectral modeling, reflectance value

A STUDY ON AMPHIBIAN DIVERSITY OF CHARJU RIVER SYSTEM, TIRAP DISTRICT, ARUNACHAL PRADESH, INDIA

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The present study was done in and around the semi torrential zone of Charju river of Tirap district, Arunachal Pradesh. It feeds the river Brahmaputra. This lotic system provides breeding ground for different species of amphibia. This is the first ever record of amphibian fauna from this district of Arunachal Pradesh. A total of 16 species of amphibian belonging to four families and eleven orders were recorded in pre monsoon and monsoon season of 2010. The amphibian fauna recorded so far belong to order Anura comprising 4(four) families, 16(sixteen) species and 11(eleven) genera. The first step in planning for biodiversity conservation at any geographic scale is to document the existing fauna as the aquatic habitats are increasingly becoming polluted thereby enhancing species decline. The present work will be an important contribution towards exploration of biodiversity in Arunachal Pradesh. Further exploration in the torrential zone of the river may lead to the documentation of fauna not recorded so far.

Key words: River Charju; Arunachal Pradesh; Amphibian Biodiversity; Tirap district; Hotspot.

AN ECOLOGICAL APPROACH TO AN INTEGRATED LIVESTOCK BASED LIVELIHOODS PROGRAMME, IN THE CENTRAL HIMALAYAN STATE OF UTTARAKHAND, INDIA

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Livestock rearing in the mountainous regions of the Central Himalayas though a traditional activity, is increasingly challenging due to an acute fodder scarcity which impacts the health and yield of livestock. Manual fodder collection from forests of both grass and broad leaved tree fodder is identified as a primary cause of forest degradation in the region. In this context the Himmotthan Society, a Dehradun based development organization initiated a project entitled the 'Integrated Fodder-Livestock Development Project (IFLDP)' with the aim to promote rural livelihoods and enhance incomes through an environmentally sustainable, integrated livestock management programme. Initiated in 2008 the project covers 90 villages in a cluster approach across six hill districts of Uttarakhand. The introduction of improved fodder grasses, shrub and tree species in common and private lands has increased fodder availability by 3.40 quintal/family, and shows a reducing trend in the collection of leaf-fodder from the forest. Availability of nutritious fodder grasses, better livestock management practices and ensuring the marketing of milk through Women Federations has enhanced livestock based livelihoods of communities and ultimately enhanced ecological restoration in the forests adjoining these 90 villages.

Key words: Forest restoration, Livestock, Fodder shortages, Van Panchayat, Micro-Enterprise, Livestock Producer Group, Livelihoods, Himalayas.

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IMPACT OF INDIRA GANDHI CANAL IRRIGATION ON THE STATUS OF MAMMALS IN THAR DESERT OF RAJASTHAN

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The study was undertaken to assess the impact of changes in landuse pattern on relative abundance of mammals in the Indira Gandhi Canal Area of Thar Desert of Rajasthan. The Thar desert is the most populous deserts of the world. Presently with arrival of very good quality water through Indira Gandhi Canal the region has opened up for colonization. The mammal species namely; wolf, *Canis lupus pallipes*; Jackal, *Canis aureus aureus*; Desert fox, *Vulpes vulpes pusilla*; Bengal fox, *Vulpes bengalensis*; Desert cat, *Felis silvestris*; Wild boar, *Sus scrofa cristatus*; Black buck, *Antelope cervicapra*; Chinkara, *Gazella bennetti*; Blue bull, *Boselaphus tragocamelus*; Desert hare, *Lepus nigricollis dayanus*; and Porcupine, *Hystrix indica*, were studied in Sri Gandhinagar, Hanumangarh, Bikaner and Jaisalmer districts. As compared to the human population of 30 persons/sq. km. in 1961, it has rise to 83.5 people/sq.km. The study has revealed that one of the causative agent of impact on the biodiversity in this desertic region is sand dune transformation from grassland to irrigated cropland. Due to flood irrigation in sandy and saline soils the farmers are facing water logging as well as the assemblage of water in smaller as well as larger tanks. Probably the mightiest ecological change in the Indira Gandhi Canal region is the enhancement of soil moisture. Most of the mammals are fossorial and the typical desert elements do not find high humidity environment in their burrows quite conducive to their existence. It is worth mentioning that when the canal water was not available in 150 mm rainfall zone maintained moisture within 10-20 cm depth for a week or so. But now the humid conditions are prevailing throughout the year. The availability of green food increases the reproductive potential of most of the animals. The impact of this factor has been observed very carefully through the abundance of Chinkara and Porcupine. Another very important change is that certain mammalian species like wild boar and Blue bull which never occurred in the desert zone have appeared in fairly large numbers. One of the important causative agent of impact on the biodiversity in this desert region is sand dune transformation from desert grassland to irrigated crop land. The increase in soil moisture has also affected the grassland and composition of shrubs like *Lasiurus*, *Calligonum polygonoides*, *Ziziphus nummularia*, *Haloxicon* and others.

There are number of animals which thrive in very loose sand. The two lizards namely *Phrynocephalus laungwalensis* and *Ophiomorus tridactylus* which creep under the very loose surface and because of its serpentine movement the later are know as sand fish. These species are found to perish in the Indira Gandhi Canal irrigated crop filed. In addition to these lizards a number of typical desert rodents are highly psammophilous. Presently the studies have shown that the Ganganagar region where the irrigation is in

practice for the last 70-80 years the deserticolous elements like *Meriones hurrianae*, *Gerbilus gleadowi*, *Gerbilus nanus* have already disappeared from the crop field and have been replaced by moisture loving species like *Bandicoota bengalensis*, *Millardia meltada* and *Mus musculus*. The reversal of the change in ecological niche of *Mus musculus* is very interesting and is totally a creation of human being.

Key words: Biodiversity, species distribution, environmental impacts

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FAUNAL DIVERSITY OF THAR DESERT OF WESTERN RAJASTHAN

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Thar desert of Rajasthan is situated between 22° 30' N and 32° 05' N and between 68° 05' E and 75° 45' E. It is the eastern extension of the great Sahara desert and covers 2,85,680 km². Like the other deserts of the world, the Thar desert in Rajasthan is characterized by sparse and highly variable rainfall, extreme variation in diurnal and annual temperatures and high evaporations. One of the interesting feature of this desert is its high relative humidity.

The study are represent fairly large number of animals from insects to mammals. For clarity the commonly met taxa in the study area have been included. Here, most animals are exposed only occasionally to the extremes of desert climate. They may dwell in caves, crevices, beneath stones, in burrows, under the shade of plants, on the underside of leaves and thus live in relative comfort and safety in their own microclimate of desert is therefore essential to understand the actual physical conditions in which a desert animal lives. Studies were confined to macrotaxa encountered during field surveys and information supplemented by local people. These macrotaxa and microtaxa were found in two principal habitats viz. terrestrial and aquatic. The majority of vertebrates occupy the terrestrial habitat, while the aquatic habitat is confined to most of the amphibians, all fishes, and several invertebrate groups such as some protozoan, sponges, many insects, crustaceans, molluscan, etc.

For the invertebrates, the terrestrial habitats as under stones, under leaves, under cow dung's, on trees and bushes, etc. are met with. A special types of habitat is underground burrow - small ones (used by rats, bandicoots, gerbils) and long-narrow burrows (used by termites and ants). The aquatic habitat in deserts is limited in extent. Rivers here are ephemeral, but there are a few rivulets, tanks, 'talab' and 'nadis', where rain water is available year found in normal monsoon years. In addition, there are ephemeral pools and puddles formed during the rainy season where water may last from a few weeks to a few months.

The rich insect fauna which is a characteristics role as the micro-consumer in the existing ecosystem. Although most elements of this fauna are found to be present almost throughout the year. They exhibit a high population build-up particularly during the rainy season (i.e. July to September) and cause much loss to the growing vegetation especially in this season. Among the termites, the most destructive species are *Psammotermes rajasthanicus*, *Anacanthotermes macrocephalus*, *Microtermes spp.* and *Odontermes spp.* Locusts and grasshoppers breed in the region, especially in the rain season when sufficient moisture is available in the soft-sandy soil. These pests do much loss to the growing vegetation. Swarms of the desert locurt, *Schistocerca gregaria* visit occasionally, whenever suitable environmental conditions are formed. The predatory habit of some insects like mantids (*Schizocephala bicornis*, *Statilia spp.*), Coleopteran (*Monochilis sexmaculatus*), ant (*Camponotus gigas*) and spiders are quite marked in the rainy season.

Key words: Common Property Resources, Economy, Thar Desert, Rajasthan

THREATS FOR MUGA SERICULTURE DUE TO CLIMATE CHANGE-SEARCH FOR A NEW ABODE IN UTTARAKHAND

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India is the only country which is the home for golden glittering muga silkworm and is exclusively cultivated in north-eastern and eastern part of India. Sericigenous insect caterpillar *Antheraea assamensis* Helfer feeds on primary host plants *Persea bombycina* King. (Som) and *Litsea monopetala* Juss. (Soalu). Rapidly changing climate, urbanization and civilization linked developments has altered the once unique climatic conditions and muga sericulture is in danger of losing its ground at its place. To save its life-cycle from declining in its home place and for commercial exploitation, alternate zones for seed crops were shortlisted based on host plants distribution, weather profiles and climatic extremes.

Bageshwar in Uttarakhand is in the foot hills of western Himalayas and just 40 kms far away from Pindari glacier with the varied topography of the region occupies a distinct diversified ecosystem. Localised and scattered naturally distributed primary host plants in the region, conducive weather and promising preliminary trials tempted to go in for a large scale trials of muga seed crops in the region during early 2010. The present paper enumerates in detail the trials made, critically analyses the problems that came in the way, advantages and new challenges posed before muga sericulture activities.

The results, though not to the level of boosting, provided the much needed basic seed for north-eastern region which lacked the required favourable conditions for seed crop rearing. The seed produced thus was far superior in qualitative characters over the same produced in traditional seed zones of north-eastern part of India. Further, based on these vital inputs, suggestions are put forth herewith for establishment of an alternate seed zone for muga with systematic and organized seed production and multiplication plan linked to north-eastern part of India needs for stabilized muga seed supply. The plan on implementation, shall enhance the job opportunity to the people of the region with muga silk production as subsidiary occupation.

Key words: Climate Change, sericulture

ECOTOXICOLOGICAL ASSESSMENT OF INDUSTRIAL EFFLUENT USING ZEBRAFISH BIOASSAY

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Any change in physical and chemical characteristics of aquatic environment affects organism's fitness (i.e., growth, survival, etc.) is likely to transcend the individual responses and impact on the entire aquatic ecosystem. Ecotoxicological assessment is an important aspect in wastewater quality monitoring, as it provides complete response of test organism to all component of wastewater. Toxicity test results revealed that effluent of paper mill (Pp1 and Pp5) was not toxic. 48 h LC₅₀ value for Pp3 and Pp4 was 70.71%. The acute toxicity (LC₅₀) of Pp2 ranged 35.35% to 70.71%. Linear regression analysis reflected statistical correlation between exposure concentration and mortality of fish (≥ 0.89 to 0.99) for Pp2, Pp3 and Pp4. General criteria of toxicity classification revealed that out of 5 paper mill effluents tested 3 were minor acutely toxic having 48 h LC₅₀ in between >35.35–70.71% and 2 non-toxic (>100%). The toxicity classification based on toxic unit (TU) also showed similar result.

Key words: Toxicological effect, pollution

FUTURE OF RIVER DOLPHIN (*Platanista gangetica*) IN NORTH EAST INDIA

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Present count of river dolphin in the Brahmaputra, the Barak and their tributaries is estimated to be about 250. A total of three factors, either individually or in combination relates the availability of the dolphin in a particular river- adequate water cover, water quality and abundance of prey food. As far as the Brahmaputra system is concerned, demarcation of the habitats of 'residential dolphin' and their protection through community participation may be immediately taken up. For long term action, (a) regular monitoring of dolphin population; (b) monitoring of the 'riverine health' in dolphin inhabited areas; (c) prey base (fish stock density) of most frequently sighted dolphin spots; (d) feeding and reproductive behaviour and (e) alternative livelihood for the 'affected' fishermen may be considered.

Key words: River dolphin, North East India, conservation, Barak and Brahmaputra River

MANAGEMENT OF ALIEN PLANT INVASIONS IN INDIA UNDER CHANGING CLIMATE: WHERE DO WE STAND?

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Climate change and alien plant invasions are key processes that affect global biodiversity and hence are among the most serious environmental threats. Understanding and mitigating the adverse impact of invasions on biodiversity under changing climatic conditions requires baseline information about the alien plant species growing in different habitats and regions of India, their invasion status, pathways of their introduction, spatial distribution and abundance. In addition, data on environmental variables, such as climate, elevation, land uses etc., measured or estimated across the region of interest are also needed. The spatial distributions of these variables (usually captured in a set of GIS data layers), along with a set of georeferenced sites of known species occurrence are then used to develop modelling tools for predicting species distributions. In fact, fine-scale environmental data have significantly helped in predicting the risk of invasive alien species even at a global scale.

While considerable information is available on the extent of climate change likely to occur in India, no authentic baseline information exists about the alien plants growing in India which is of paramount importance in developing a framework of risk assessment that would aid in prediction of not only the potential invasive alien species whose introduction could be prevented, but also in identification of high risk species among the already introduced species that are likely to cause ecological and economic impact. It is in this backdrop that a database of alien plant species of India based on published papers, reports, floras etc. was developed. It included 1599 vascular plant species belonging to 161 families and 841 genera. 57 species were casuals, 257 were naturalized and 225 species were invasive. This baseline database of alien plants together with environmental data would allow the development of ecological niche models that predict the potential distribution or abundance of alien species under altered climatic conditions and identify potential high-risk invaders. While this predictive modelling holds promise in management of plant invasions, necessary baseline information needs to be obtained at an earliest so as to effectively combat the menace of biological invasions in India.

Key words: Biological invasions, biodiversity, management

FLY ASH - A CHEAPER SOIL AMENDMENT FOR HEALTHY EDAPHIC ENVIRONMENT AND HIGHER FORAGE PRODUCTION

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Fly ash is a waste product generated by coal based thermal power plants. It is a complex, heterogeneous material consisting of amorphous as well as crystalline phases. In India, nearly 73% of the total installed power generation capacity is thermal, of which 90% is coal-based. Nearly 15-30% of the total amount of residue generated during burning of coal in thermal power plants constitutes fly ash. Disposal of such a huge quantity of fly ash poses challenging problems. Owing to its physico-chemical characteristics, it has a vast potential for use in agriculture, forestry and wasteland reclamation. Application of fly ash into soil has been reported to increase the water holding capacity, hydraulic conductivity, porosity and decrease bulk density, modulus of rupture and surface encrustation. An experiment was conducted at Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi. Fine textured fly ash was collected from Parichha Thermal Power Plant, U.P. and applied in the field at the rate of 50 and 100 tonnes per hectare with sole inorganic and with integration of organic and biofertilizers in the *kharif* season of 2004. Sorghum (PC-6) intercropped with cowpea (BL-1) in *kharif* was grown followed by oat in *rabi* for consecutive three years without disturbing the experimental plots. Fly ash was applied only once at the beginning, whereas recommended doses of fertilizers and manures were applied in every season. The experiment was planned in Completely Randomized Block Design with nine treatments and three replications. The physical, physiochemical and chemical properties of soil and fly ash were analyzed following standard procedures described in literature.

The bulk density and particle density of both the soils were reduced due to fly ash application. After three years, the water retention at 1/3 bar in the soil was 1.05 and 0.39 % more than the control in soil treated with fly ash @ 50 and 100 t ha⁻¹ respectively. Fly ash application resulted in increase of organic carbon and total phosphorus but reduced the total sulfur. This fine-textured fly ash also increased the content of B, Cu, Zn, Ni, Co, Cr, Pb, Mo and As in soil and at the same time a decrease in the content of Fe and Mn. At the end of three years of experimentation, it was observed that the levels of radionuclides (⁴⁰K, ²²⁶Ra and ²²⁸Ac) and heavy elements were well within the safety limits. Though it was observed that fly ash had a suppressive effect on soil dehydrogenase activity, especially at higher dose (100 t ha⁻¹), use of FYM and biofertilizers reduced the negative effect of fly ash on the enzyme activity.

Application of fly ash significantly affected the green forage yield of sorghum and cowpea in *kharif*. Maximum forage yield was recorded where 50 t ha⁻¹ fly ash and integrated source of nutrient (1:1 organic-inorganic) were used. In *rabi* also maximum green fodder yield of oat was obtained through the use of fly ash with 1:1 ratio of organic manure and inorganic fertilizer. The yields obtained from 50 and 100 t ha⁻¹ fly ash were statistically at par.

The results from field experimentation and laboratory analyses lead to a definite conclusion that application of fly ash in soils having some limitations in their physical properties like that used in present experiment, resulted in significant increase in yields of forage crops. The cause of enhancement in crop production was explored and major factor responsible for it was found to be improvement in physical properties of soil, e.g., increase in water retention capacity in light soil. Organic manures also improve the soil physical conditions and microorganisms present in biofertilizers work more efficiently under this situation. All those materials when added with fly ash, their synergistic effect were translated into enhanced yield of the crop.

Key words: Environmental impacts, fly ash, biological production

INVASIVE SPECIES AND ECOSYSTEM SERVICES OF INLAND FRESH WATERS IN A CHANGING CLIMATE

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The inland freshwater ecosystems (rivers, lakes, wetlands) support a significantly large biodiversity greatly disproportionate to their total area, and provide a host of ecosystem services. They are also the most threatened ecosystems because they bear the brunt of all anthropogenic activities in their catchments as well as within them. Hydrological alterations, loading of nutrients and sediments, and the disposal of organic and toxic wastes constitute the primary and greatest threats to the biodiversity and functioning of these ecosystems. The next most important threat comes from the alien invasive species whose invasion is often facilitated by the changes in hydrology and water quality. Global climate change has emerged as another major factor whose impacts synergise with those of other anthropogenic activities. The responses of various inland freshwater ecosystems to these factors have been discussed in many publications. This paper examines the impacts of invasive species, with the examples of water hyacinth and tilapia, on the freshwaters in terms of their ecosystem services and the likely compounding effects of climate change.

Ecosystem services are the direct and indirect benefits derived by humans from the functions of the ecosystems. The Millennium Ecosystem Assessment (2005) grouped them into Provisioning, Regulating, Cultural and Supporting services. Ecosystem functions themselves are derived from the ecological processes that are the same across ecosystems. For example, photosynthesis and the associated processes lead to the ecosystem function of primary production on which all consumers depend. The production of biomass is valued as an ecosystem service. It is a Provisioning service in so far as the plant biomass is utilised by the humans for food, feed, fibre, fuel, timber or similar benefits. It is also a Regulating service considering the importance of long-term biomass accumulation to mitigation of climate change through carbon sequestration. Appropriate partitioning of the biomass between the belowground and aboveground organs regulates soil erosion and hydrology. Similarly, the secondary production of biomass through food chain interactions also is valued as a Provisioning service.

However, the ecosystems functions often have negative values and hence there are costs associated with them instead of benefits. The ecosystem services then become disservice. The invasive species, mostly alien species, through the same ecological processes alter the pathway, rates and magnitudes of the ecosystem functions in such a manner that these functions become a disservice to humans. This is best exemplified by water hyacinth and tilapia. Water hyacinth is a rapidly multiplying exotic perennial with very high biomass production (up to 100 mg ha⁻¹ yr⁻¹). Numerous attempts have been made to project the value of this biomass to humans. The plants, after their death, decompose very slowly and hence contribute to large amounts of carbon accumulation over time. At the same time, water hyacinth mats are also known to contribute to methane emissions. The dense growth of water hyacinth, however, significantly alters the biotic community and has several adverse impacts on water quality and the utilisation of the water body itself by the humans, besides influencing the aesthetics. Tilapias which are native to Middle East and parts of Africa, are important food fishes with high population growth rate and wide ecological amplitude. These omnivorous fishes have become highly invasive in all parts of the world causing decline of indigenous fish species and other biodiversity. Their hybridisation with other cichlids has resulted in genetic contamination of indigenous fish populations, and they have also facilitated the spread of fish parasites. Thus, the food chain function of an omnivore like tilapia provides an important Provisioning service but has a strong negative impact on biodiversity which in turn affects other ecosystem functions.

This brings into picture the ecological economics – the valuation of ecosystem services. Most valuations of ecosystem services consider only one or a few of them with indirect benefits or costs. A comprehensive estimation of the total economic value (TEV) by taking into account all costs and benefits of all ecosystem services is missing as yet. The growing tendency to promote utilisation of the invasives as a resource has not only aggravated their negative impacts on freshwater ecosystems and hence, accelerated loss of their important ecosystem services, it has also affected proper valuation.

Finally, a word about climate change. Climate change will directly impact upon the aquatic ecosystems through increased spatial and temporal variability of precipitation regimes and extreme events as well as the human response to the changes in the available water resources. There is growing evidence that the ongoing climate change will also accelerate and intensify the spread of invasive species. The freshwater ecosystems are projected to face a greater threat from invasive species which will invade newer areas. Hence, the impacts of invasive species need to be evaluated after considering all ecosystem services in the context of climate change.

Key words: Water hyacinth, tilapia, carbon sequestration, biodiversity

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MULTI LOCATION EVALUATION OF HIGH YIELDING PROVENANCES OF BHIMAL (*GREWIA OPTIVA* J.R. DRUMMOND EX BURRET) – A MULTIPURPOSE AGROFORESTRY TREE SPECIES OF NORTH WESTERN HIMALAYAS

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In view of prime importance of Bhimal tree for green lopped fodder in agroforestry systems of north-western middle Himalayas, high yielding provenances (HYPs) were identified through an extensive evaluation over 10 years at CSWCRTI, Dehradun. One year old saplings of 3 high yielding provenances I.C. Bhaintan, I.C. Chamba and I.C. Malas were planted at 4 different elevation in middle Himalayas comprising Doon Valley and higher elevations upto 2000 ha in District Tehri Garhwal and Chakrata hills of District Dehradun in 2006. Marked differences in growth parameters of bhimal were recorded within one year of planting at different sites and could be attributed to diverse climatic and edaphic conditions at different sites. After imposing lopping treatment in 3rd year after planting productivity potential of high yielding provenances was better expressed at Valley locations than at higher elevation. I.C. Bhaintan and I.C. Malas were the most productive provenances at Valley location which I.C. Chamba was the most productive at higher elevation in respect of fresh weight of lopped fodder and dry fuelwood weight.

Key words: Bhimal; Provenances; Agroforestry Tree; Gree Fodder; Multilocation; Evaluation

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SCREENING AND ASSESSMENT OF *AZOTOBACTER* SPP. IN ENVIRONMENT MANAGEMENT FROM MANGROVE RHIZOSPHERE OF WESTERN COAST OF INDIA

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The mangrove ecosystem is an important intertidal estuarine wetland along the coastline of tropical and sub-tropical regions. They provide a unique ecological niche to different microbes which play various roles in nutrient recycling as well as in the environment management. Rhizospheric regions of mangrove plants harbor different N fixing bacteria including *Azotobacter* species. They are free living, obligate aerobic soil bacteria, enhancing plant growth by the process of N₂ fixation. They are able to survive in the highly saline mangrove soils. The mangrove forest in the western coast of Mumbai is rich in flora and fauna but is under intense stress due to the release of the industrial effluents and dumping of garbage and construction wastes.

The effluents and wastes contain various metals, dyes, phenolic and polymeric compounds. Microorganisms thriving in such a stressful habitat may act as a tool to combat the problems of environment degradation. Hence, the present study was aimed at the isolation and characterization of *Azotobacter* species from mangrove forests of the western coast of Mumbai and their assessment in the degradation of basic dye (crystal violet) and survival potential in heavy metals (Zn and Cu), 2-chlorophenol and polymer (polyethyleneimine).

Soil samples were collected between the depths of 10-15 cm from two sites of mangrove forest in Mumbai. Site I situated in Airoli (Navi Mumbai) was polluted with industrial effluents, domestic and construction wastes. Site II at Godrej Mangroves, Vikhroli, Mumbai, was protected from human encroachment and considered as control in the study. The *Azotobacter* was isolated on N free Jensen's media and plates were incubated at 28-30°C for 24- 48 hrs. After the purification of colonies the isolates were enriched in N free Jensen's broth. Isolated colonies were characterized and assessed for growth in heavy metals, dye, 2-chlorophenol and poly ethylene imine as per the standard methods. Dye decolorization was also assessed.

The characteristic features of *Azotobacter* spp. such as polysaccharide production, IAA production, phosphate solubilisation, ammonia production, etc were found to be positive for the two isolates. Both isolates enhanced seed germination in maize. These characteristics of the two isolates confirmed it to be of the *Azotobacter* species. Both the isolates showed decolourisation of crystal violet and slow growth of *Azotobacter* with increasing concentration of crystal violet. The growth and decolourisation percentage of isolate I was better in comparison to isolate II. The percent decolourisation of the crystal violet by isolate II decreased with increasing concentration while in Isolate I it was less (21.44%) at 100mg/l concentration, increased (22.55%) at 150mg/l concentration and again decreased (19.36%) at 200 mg/l of the dye.

Isolate I exhibited growth on all concentrations of zinc and up to 2.5% concentration of copper, while growth was ceased on 5% concentration of copper. The isolate II exhibited growth on all concentrations of copper and zinc.

The isolates I and II showed growth on all concentrations (0.25%, 0.5%, 0.75% and 1%) of 2-Chlorophenol upto 10 days. Both the isolates presented growth on all concentrations of the polyethylene imine by forming bacterial clump. The capability of the *Azotobacter* isolates to survive in toxic concentrations of metals, phenol and polymer and its immense potential in degradation of dyes, serves it to be an efficient and very promising tool in environment management.

Key words: Environmental management, mangroves, azotobacter

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TOXIC EFFECT OF CADMIUM COMPOUNDS (-CHLORIDE, -SULPHATE, -NITRATE) ON AIR BREATHING FRESHWATER FISH *CHANNA PUNCTATUS* (BLOCH, 1793): A COMPARATIVE TOXICITY ANALYSIS ON MORPHOLOGICAL & BEHAVIOURAL CHANGES

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Cadmium compounds are serious pollutants of aquatic environment because of their environmental persistence and ability to be accumulated by aquatic organisms. In the present study, a comparative statement of the lethality of different concentrations of cadmium compounds ($\text{CdCl}_2 \cdot \text{H}_2\text{O}$, 600ppm to 650ppm; $\text{CdSO}_4 \cdot 8/3\text{H}_2\text{O}$, 600ppm to 850ppm; and $\text{Cd}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$, 900ppm to 990ppm) and their toxicological effects on morphology and behaviour of widely consumed Indian snakehead fish *Channa punctatus* was observed for 24 hours. The LC_{10} - LC_{90} value for all the three compounds were calculated according to Probit analysis. Among morphological and behavioural changes fish showed distinct changes

as compared to control in higher concentrations for Cd(NO₃)₂.4H₂O (>900ppm) but in low concentrations for CdCl₂.H₂O & CdSO₄.8/3H₂O₄ (<800ppm). In conclusion, among three tested compounds of cadmium, CdCl₂.H₂O was highly toxic while Cd(NO₃)₂.4H₂O was comparatively less toxic to freshwater fish *Channa punctatus*.

Key words: Cadmium toxicity; *Channa punctatus*; LC₅₀; Morphological changes; Behavioural changes.

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PURIFICATION OF WASTE WATER BY USING A LOW-COST CONSTRUCTED WETLAND IN ONSITE RURAL ENVIRONMENT

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Waste water is one of the major problems in rural environment in the developing country like India, where waste water is collected in one end of village and cause health hazards and other nuisance. A low-cost constructed wetland can solve the problem of collection of waste water as well as its health hazards and other nuisance. Constructed wetlands for wastewater treatment is a man-made marsh; designed, built and operated to simulate the water quality improvement function of natural wetlands. In rural wastewater treatment, subsurface flow wetlands maintain all water below the ground surface to satisfy health related issues. By passing the filter layers of gravel, soil, vegetation (*Typha angustata*) and microorganisms, the water is treated not only by microbial activity, but also by adsorption processes. The extraction and later decomposition of persistent organic compounds as well as the removal of pathogens is best in this combined system which results in hygienic water quality standards. The treated wastewater is collected at the end of the bed by a gravel layer with discharge into a small control shaft at one corner of the wetland. The wastewater is transferred by gravity into a collection tank and either reused for irrigation of the crops, bathing of animals or toilet flushing.

Key words: Constructed wetland, Waste water, *Typha angustata*, Health hazards

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FAUNAL DIVERSITY OF ARID REGION: A CASE STUDY FROM GULBARGA AND YADGIR DISTRICTS OF NORTH KARNATAKA, INDIA

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A study was conducted in arid region located in Gulbarga and Yadgir districts of Karnataka, India. This is one of the hottest regions of the country. In India, arid regions are sensitive to climate change-induced impacts thus need immediate attention for conservation of valuable plant and animal species available in this region. In study region we have found rich faunal diversity. We have conducted various seasonal experiments to study the fauna of the region. We have recorded the species belong to different animal groups of the animal kingdom viz., Arthropods (more than 300 species), Mollusks (3), Pisces (6), Amphibians (4-5), Reptiles (more than 10 species), Aves (24), and Mammals present in this arid region. We have calculated high species richness in the region, for example we were able to collect 298 species of spiders in small locality of the study region. This study was undertaken in view to understand the human, plant and animal interactions under the parameter of sustainable socioecological development. Based on the present study we suggest that, more efforts are needed towards conservation and management of arid-

ecosystems of the country. Our work in this endeavor is continued and these are initial research results from our own empirical field work in the arid region of the Karnataka, India.

Key words: Arid regions; Biodiversity; Conservation, Climate Change

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DEVELOPMENT STRATEGY OF INDIA UNDER THE LOW-CARBON ECONOMY

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India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. In order to cope with the climate change and to promote India's economic growth and the energy security, low carbon economy should be adopted. A country's energy policy will be immediately impacted by a transition towards a low carbon economy. The Government of India is implementing increasingly wide- reaching regulations and incentives to reduce emissions and is preparing adaptation plans and has planned reductions in carbon intensity of its economy by launching National Action Plan on Climate Change (NAPCC). Under the NAPCC, several initiatives have been planned which will propel low carbon investments in India as well as better management of water, natural habitats and human settlements. Energy efficiency related policies and measures such as Energy conservation Act 2001, Perform Achieve and Trade (PAT), Market Transformation for Energy Efficiency (MTEE), Programmatic CDM, Standards & Labeling, Energy Conservation Building Code 2007, Electricity Act 2003 etc. are in force to deliver the priority missions related to energy efficiency and renewable energy. The government is putting in place incentives, fiscal measures and preferential arrangements such as feed-in-tariffs to attract investors and enable projects to be commercially viable. In India carbon finance is interpreted to mean a financial mechanism that is derived from the carbon credit revenue stream generated from a clean project registered as CDM project under Kyoto Protocol.

Key words: Low carbon economy, energy efficiency, NAPCC, Government of India.

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STRUCTURE AND COMPOSITION OF PLANT-BIODIVERSITY IN ARID REGION IN GOGI-GULBARGA-KARNATAKA

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The conservation, management and sustainable resource utilisation of forests are crucial issues keeping in view the changing climate and associated hazards. The arid regions of India cover over about three lakh km² and are spread over six States of the country. The arid regions are most vulnerable to climate change. Therefore, it is imperative to inventory the plant biodiversity of the arid regions for conservation and management of this vulnerable agro-ecological region. In this endeavour we have conducted detailed phytosociological study in the arid region of north Karnataka to understand the effect of disturbances on structure of vegetation. In arid zones, vegetation is typically sparse. But we have recorded the high diversity (species and beta diversity) in the study region. During the study period we have recorded a total of 169 plant species comprising trees (17 per cent), shrubs (23 per cent), herbs (39 per cent), and creepers (20 per cent) belonging to more than 69 different families of the plant kingdom, such as *Mimaceae*, *Fabaceae*, *Cesalpiniaceae*, *Amaranthaceae*, *Euphorbiaceae*, *Meliaceae*, *Annonaceae*, *Poaceae*, *Asteraceae* etc. High density of tree species viz., *Prosopis juliflora*, *Leucaena leucocephala*, *Acacia nilotica*, *Acacia leucophloea* forms the top story vegetation of the studied arid landscape. Species like *Casia auriculata*, *Abutilon indicum*, *Canthium coromandelicum* and *Euphorbia tirucalli* contribute in making the secondary

vegetation layer. The top story vegetation in studied ecosystem was dominated by *Prosopis juliflora* (303 individuals per ha). Least individuals of the species such as *Cordia dichotama* and *Ficus bengalensis* (3 individuals/ha), *Cassia fistula* (10 individuals/ha) are recorded from the studied ecosystem. This paper discusses how a few additional efforts can save biodiversity of arid region and contribute to promote innovative solutions to reduce threats to biodiversity in view point of changing climate, growing population, change in land use and land cover in arid ecosystems of the country.

Key words: Plant-biodiversity, Land Use Land Cover, Arid Region, Species Diversity, Beta diversity

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POTENTIAL OF *EISENIA FETIDA* FOR RECYCLING FOOD INDUSTRY WASTE

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The earthworms act as 'soil conditioner' to improve the physical, chemical and biological properties of soil and its nutritive value. They swallow large amount of soil with organics (microbes, plant & animal debris) everyday, grind them in their gizzard and digest them in their intestine with aid of enzymes. Due to unplanned industrialization large amount of waste is generated throughout the world from different industries, creating environmental problems. The waste generated from these industries usually disposed in open, which are a potential source of pollution to environment cause hazards to human health. Vermicomposting has been considered as a way of transforming some of these organic wastes into useful soil conditioner, i. e., vermicompost for plants and soil while diminishing their negative environmental effects. The objectives of present study were to investigate the potential of earthworms (*Eisenia fetida*) to transform food industry sludge amended with cow dung into vermicompost 3 months laboratory scale experiment. There was a significant decrease in pH, TOC and C: N ratio, but increase in EC, TKN, TK and TAP was recorded in the vermicompost than the initial wastes. The heavy metals content in vermicomposts was higher than initial wastes. It was inferred from the study that addition of 30 to 40% of food industry sludge with cow dung had no antagonistic effect on the manurial quality of vermicompost. These experiments demonstrate that use of *Eisenia fetida* worms can be an alternate technology for recycling and environmentally sustainable management of food industry waste (if mixed in appropriate quantities with cow dung).

Key words: Food industry sludge; *Eisenia fetida*; heavy metals; C: N ratio Vermicomposting.

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LONGITUDINAL DISTRIBUTION OF BENTHIC COMMUNITIES IN THE HIGHLAND RIVERS OF INDIA

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The species richness of diatom community declines from source to mouth in the Bundelkhand rivers Ken and Tons over 300 km in length but hardly decreases in the ca. 100 km long Paisuni. In a lesser Himalayan springfed stream over 100 km long, the richness increases marginally from source to mouth. In 194.8 km segment of the mountain stretch of the Alaknanda-Ganga the richness increases from 74 to 142 taxa from the upper to lower stretch. A study on the streams of Mandakini basin shows that the richness decreases from high to low altitude. In both Bundelkhand and Himalayan region this is attributable to reduction in particle size of the substrate from source to mouth. However, decrease in particle size reduces substrate

heterogeneity in the Bundelkhand as clay, silt and sand prevail in contrast to boulder, cobble, pebble, gravel in the Himalaya. The richness of macroinvertebrate community also shows similar trend in respective regions, except the headwaters (upper section). The density of both communities shows increasing trend in the Himalaya but declining trend in the Bundelkhand rivers.

Key words: Mountain, Bundelkhand,

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TOXICITY IMPACT OF ARSENIC ON BLACK GRAM AND ITS AMELIORATION USING PHOSPHATE

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The objective of the study was to investigate the effect of different concentrations of arsenic on black gram (*Vigna mungo* var. PU19). Plants grown in earthen pots were evaluated after 45 days of sowing for change in morphological, physiological and biochemical features. Arsenic (As) greatly reduced the germination percentage, shoot and root length of plant. Photosynthetic pigments like total chlorophyll, chl a, chl b and carotenoids were also reduced at higher doses of arsenic. Catalase activity level did increase in the lower doses of As to combat oxidative stress produced by arsenic but its level decreased at higher doses. Arsenic increased electrolyte leakage in black gram plants. Joint application of phosphate with higher doses of arsenic showed positive alterations in all parameters leading to better growth in plants.

Key words: Arsenic; *Vigna mungo*; Photosynthetic pigments; Catalase; Phosphate

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BUTTERFLY DIVERSITY OF ARID REGION: A CASE STUDY OF NORTH KARNATAKA, INDIA

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A study was conducted to examine the species richness of butterflies in arid region of north Karnataka, India. We have found 17 species of butterflies in small land cover and evaluated their presence with changing land use and land cover of the region. Some species are recorded as indicator species of climate change. We used the transect walks method to count the butterfly species in the study region. We used netting method to collect the butterfly for the species identification. We have found that some of species are very much prevalent in and around agricultural land and some are confined to the bushes and forests of the region. Thus we suggest that drastic land use change and along high use of purchased inputs would affect the population and species of butterflies. The arid, semi-arid regions are more vulnerable to climate change and therefore, much scientific interventions are required to sustainable landscape development in arid regions which are being neglected in comparison to other rich bio-diverse regions of the country.

Key words: Butterflies; Arid region; Conservation; Climate change; Sustainable landscape development

BUILDING ON THE INDIGENOUS KNOWLEDGE ABOUT FUNCTIONS OF BIODIVERSITY: A SYNTHESIS OF CASE STUDIES FROM INDIAN HIMALAYA

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Village landscape analysis in a range of socio-ecological scenarios in Himalaya, viz., Spitian tribes in cold desert, Garhwalis-Kumaonis in temperate-subtropical region and Adis in tropical humid region reveal that local communities value biodiversity primarily for coping with the risks and uncertainties of a monsoon climate, spatial variability in factors determining crop yields, market and policy interventions. Further, local communities take an integrated view of costs and benefits associated with wild and domesticated biodiversity. Forest/pasture biodiversity and ecosystem functions were the key determinants of agroecosystem productivity and ecological functions. Cultural norms favoured equity by allowing income from non-timber forest products only to small land holders and hiring of agricultural labor only from within the village community and biodiversity conservation by designating highly fragile ecosystems, e.g., forests around hill tops and streams and on steep slopes with shallow soil) as sacred areas with no consumptive uses, religious faiths in natural resource utilization-regeneration practices, exchange of high quality seeds and dissemination of indigenous innovations (e.g., domestication of medicinal plants, palms and trees) free of any cost/benefit consideration, allowing collection of rare plants (e.g., medicinal plants) only to traditional healers for their subsistence and by severe penalties for violation of the norms. However, these positive elements of indigenous knowledge have not found proper place in environment-development policies and programmes partly because of lack of scientific efforts on validation of indigenous knowledge and its enhancement with conventional scientific inputs.

Key words: Indigenous knowledge systems, sustainable development

STUDY OF TEMPORAL VARIATION IN PHYSICO - CHEMICAL CHARACTERISTICS OF SOME WATER BODIES OF KURUKSHETRA

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The present study deals with water quality assessment of some water bodies of Kurukshetra, in view of their religious importance and ecological sustainability. Three holy tanks (Braham Sarovar, Sannihit Sarovar, Jyotisar) and one pond (Bhor Saida - crocodile breeding center) were taken under consideration. Limnological studies of these water bodies were carried out during March and April month 2009, in three phases. First phase sampling was done during the middle of the March, 2nd phase during the end of the March, and 3rd phase during the middle of the April. For studying the pollution status of these water bodies certain pollution parameters were taken such as, pH, EC, TDS, COD, TH, Carbonates, Bicarbonates, Chloride, Alkalinity, Sodium, Potassium. The mean temperature increase from March to April was 26 - 33° C. associated with the increase in temperature the maximum and minimum range of physico - chemical parameters were as, pH varied from 6.60 to 7.83 during initial phase of sampling and 6.79 to 8.75 during last phase of sampling. EC ranged between 2.8 - 3.8 and 2.5 - 3.6 mS during initial and middle phase of sampling respectively, Salinity increased in all the water bodies except Bhor Saida from March to April. Bhor Saida showed highest value to TDS, followed by Jyotisar and Braham Sarovar respectively, chloride and sodium value varied between 10.5 - 25.4 mg L⁻¹ and 5- 14 mg L⁻¹ during initial phase of sampling, 12.2 - 22.3 mg L⁻¹ and 3-12 mg L⁻¹ during middle phase of sampling respectively. No significant variation

was observed in Bicarbonate and COD concentration from March to April in all the water bodies. Alkalinity ranged between 32 – 72 mg L⁻¹, 32 – 74 mg L⁻¹ and 38 – 72 mg L⁻¹ during all sampling periods. The analysis shows that the quality parameters are well within permissible limits in all water bodies. However, Jyotisar and Sannihit Sarovar show a slightly higher value in some parameters than Braham Sarovar and Bhor Saida and it is concluded that the variation in parameters were due to increase in temperature and increase in rate of evaporation from March to April.

Key words: Physico – chemical properties, Braham Sarovar, Sannihit Sarovar, Bhor – Saida, Jyotisar, Kurukshetra.

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DERIVING LARGE-SCALE REGIONAL PATTERNS FOR LONGITUDINAL CHANGES IN THE HIGHLAND RIVERS OF INDIA: SPECIES RICHNESS AND DENSITY

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The community features like number of species and density are known to increase longitudinally in individual rivers in different geographical regions. Do all streams/rivers within and among the regions show a similar trend?

The species richness of diatom community declines from source to mouth in the Bundelkhand rivers ca. 300 km long Ken and Tons but hardly decreases in ca. 100 km long Paisuni. In the lesser Himalayan spring-fed stream about 100 km long, the richness increases marginally from source to mouth, but in the 194.8 km Himalayan segment of the Alaknanda-Ganga the richness increases from 74 to 142 taxa from the upper to lower stretch. These trends are attributed to differences in substrate heterogeneity. In the Bundelkhand region reduction in particle size to clay, silt and sand downstream of the source creates homogeneous substrate. In the Himalaya particle size reduces to boulder, cobble, pebble, gravel increasing substrate heterogeneity. The richness of macroinvertebrate community also shows similar trend except the headwaters upper section of the Bundelkhand rivers. The density of both communities shows increasing trend in the Himalaya but declining trend in the Bundelkhand rivers.

Substrate homogeneity is detrimental to species richness and density of benthic communities. These eastuaries vary longitudinally within and among the regions. Studies in the Himalaya show that a river and a region approach produce different results. Hence results from one river or region cannot be extrapolated to other river or region. The developmental activities that result in substrate homogeneity will be detrimental to benthic communities that lie at the base of food webs.

Key words: Biodiversity, change detection

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PARASITOLOGICAL DATA AS INDEX OF ECOSYSTEM STRESS IN KASHMIR HIMALAYAN WATERS

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This analysis represents an attempt to test the idea that fish parasite infrapopulations could play an important role as bioindicators of ecosystem stress. A comparative study was undertaken to elucidate the role of host habitat characteristics on abundance and spatial distribution patterns of parasites in some cyprinid fishes. We used data sets from three lakes of differing pollution level in Kashmir namely Anchar (highly polluted), Dal (polluted) and Manasbal (slightly polluted). The lakes were chosen to provide a broad

range of morphology, trophic status and human disturbances. We applied for the first time the altered core-satellite species concept to analyze the local status and distribution of some parasite species in different populations of hosts. The simultaneous use of both limnological and parasitological data facilitated the interpretation of the observed variations along the pollution gradient of lakes. The results of this study showed that the habitat characteristics of hosts contributed significantly to locality differences in ranks of the different parasite species and highlighted the immense potential that the parasite fauna possesses in addressing the trophic vis-à-vis health status of lake ecosystems.

Key words: parasites; fishes; lakes; ecosystem health; eutrophication

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DRINKING WATER QUALITY WITH RESPECT TO FLUORIDE

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The objective this study was to analyze the drinking water quality with special reference to fluoride. A total of 12 drinking water samples in the studied locations were assessed for fluoride and other water quality parameters from Ferojpur-Jhirka town of Gurgaon district of Haryana. The fluoride content ranged from 1.00 to 1.90 mg/L. At five locations fluoride content was higher than maximum permissible limit. The results revealed that the quality of drinking water at Ferojpur-Jhirka town of Gurgaon district is very poor, which can be used for drinking and cooking only after prior treatment.

Key words: Drinking water, fluoride, electrical conductivity, total dissolved solids.

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THE ROLE OF *PROSOPIS CINERARIA* IN BIODIVERSITY CONSERVATION OF ARID ZONES

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A study was carried out to assess role of *Prosopis cineraria* in conservation of arid regions of Thar desert *Prosopis cineraria* (L.) Druce Khejri is a versatile species, providing fodder, fuel food, timber, and shade to the adjacent biodiversity, as well as affecting soil improvement and sand dune stabilization in arid zones of Thar desert. It is commonly used in dryland agroforestry in India and Pakistan, thus a keystone species of these agroecosystems. The tree is known locally as jandi or khejri (India), jand (Pakistan), and ghaf (Arabic). Its synonym is *P. spicigera*. Since in arid regions, this is the only tree species, it provides much needed shade and shelter to the farmers working in the fields as well as to the cattle and wildlife during the scorching heat months. Pods of Khejri are eaten by cattle, sheep, horses, mules, donkeys, goats, camel and other wildlife in desert especially black buck, Neelgai and chinkara in western Rajasthan have survived by eating pods and leaves of this tree. It is most important top feed species providing nutritious and highly palatable green as well as dry fodder, which is readily eaten by camels, cattle, sheep and goats, constituting a major feed requirement of desert livestock. Due to its extensive root system it stabilizes shifting sand dunes and is also useful as windbreak shelterbelt and in afforestation of dry areas. It fixes atmospheric nitrogen through microbial activities. It adds organic matter through leaf litter decomposition thus rejuvenating poor soils. Moreover this tree supports higher population of microorganisms in its vicinity. But in the recent past due to overgrazing, excessive lopping, insect pest attack and indiscriminate cutting led to decline in its density in highly fragile arid zones. So there is an urgent need for a strenuous effort towards conservation of the desert's biodiversity especially indigenous multipurpose trees such as *P. cineraria* which also supports other forms of biodiversity.

Key words: Arid, biodiversity, Khejri, *Prosopis cineraria*, Thar.

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FUNGAL DIVERSITY CHANGE IN RHIZOSPHERIC AND NON – RHIZOSPHERIC SOIL FROM PETROLEUM CONTAMINATED SITES

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Increasing demand for petroleum and associated products during last ten decades has made petroleum spills inevitable consequences of oil production and refining. Various products of crude oil will remain a major source of energy in the next several decades. Although alternate sources are present but a reliable alternative has not yet been found. So, the problem of pollution during processing, production and transportation of oil would remain a major issue. Mechanical and chemical methods generally used to remove hydrocarbons from contaminated sites have limited effectiveness and can be expensive. Today one of the best approaches for restoring contaminated soil is to make use of the microbial degradation (bacteria and fungi), which is cost-effective, most environmentally friendly and will lead to complete mineralization. Individual microorganisms are capable of degrading only a limited number of crude oil components; therefore, more extensive degradation of oil depends on the presence of metabolically diverse microbial communities. Microbial diversity, the richness of species in environmental sites, provides a huge reservoir of resources which we can utilize for our benefit. The ability of fungi to transform or metabolize chemical pollutants and aerobically degrade a wide range of PHC's has received much attention due to environmental persistence and chemical toxicity of PHC's. The fungal degradation of xenobiotics is looked upon as an effective method of removing these pollutants from the environment because fungi primarily degrade poorly available pollutants, finally making them more susceptible to bacterial degradation. Under some conditions fungi may even be more effective degraders than bacteria, since the initial attack on high molecular weight hydrocarbons by fungal exoenzymes may give them advantage compared to bacteria in soil.

In present study, fungal species were isolated from rhizospheric soil and non- rhizospheric soil and the pure strains of all fungal isolates obtained were identified and morphological characteristics of fungal spores and hyphae were studied. It was observed that the total number of fungal species were higher in rhizospheric soil as compared to non – rhizospheric soil. Identified strains of fungi were *Aspergillus sp.*, *Fusarium sp.*, *Alternaria sp.*, *Rhizopus sp.* and *Penicillium sp.* Most abundant fungus species was *Aspergillus* in both type of soil. *Fusarium sp.* was present only in rhizospheric soil. The types of fungal species were also less in non – rhizospheric soil compared to rhizospheric soil. The growth pattern of these native fungal isolates was comparable to control even at 2.5% diesel concentration. This reflects the adaptability of these isolates to grow on petroleum contaminants and ability to degrade them.

Key words: Fungal diversity, Crude oil, Rhizospheric soil, Adaptability, Diesel

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VERMICOMPOSTING - A TECHNIQUE FOR WASTE MANAGEMENT IN RURAL ENVIRONMENT

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Rural environment has facing the biggest problem of solid waste, mainly animal dung and house hold waste. Vermi-composting seems to be one of the most appropriate technologies for Indian farmer to solve the problem of these waste materials and convert in useful and valuable compost. It has been also

found that this technology is not only an appropriate one but also can play a role of missing link between chemical and organic agriculture to Indian farmer.

Vermicomposting can do with following requirement i) Housing: Sheltered culturing of worms is recommended to protect the worms from excessive sunlight and rain. ii) Containers: Cement tanks were constructed. These were separated in half by a dividing wall. Another set of tanks were also constructed for preliminary decomposition. iii) Bedding and feeding materials: During the beginning of the project, most villagers used cow dung in order to breed sufficient numbers of earthworms. Once they have large populations, they can start using all kinds of organic waste.

The bedding and feeding materials are mixed, watered and allowed to ferment for about two to three weeks in the cement tanks. During this period the material is overturned 3 or 4 times to bring down the temperature and to assist in uniform decomposition. When the material becomes quite soft, it is transferred to the culture containers and worms ranging from a few days to a few weeks old are introduced into them. A container of 1 meter by 1 meter by 0.3 meters, holds about 30-40 kgs of the bedding and feeding materials. In such a container, 1000 - 1500 worms are required for processing the materials. The material should have 40-50 % moisture, a pH of 6.3-7.5, and a temperature range of 20-30 °C. The earthworms live in the deeper layers of the material. They actively feed and deposit granular castings on the surface of the material. The worms should be allowed to feed on the material until it is converted into a highly granular mass.

The earthworms take 7 weeks to reach adulthood. From the 8th week onwards they deposit cocoons. One mature worm can produce two cocoons per week. Each cocoon produces 3-7 young after an incubation period of 5-10 days depending on the species of worms, quality of feed and general conditions. The resulting increase is about 1200-1500 worms per year. The population doubles in about two month's time.

The harvesting of vermicompost involves the manual separation of worms from the castings. For this purpose, the contents of the containers are dumped on the ground in the form of a mound and allowed to stand for a few hours. Most of the worms move to the bottom of the mound to avoid light. The worms collect at the bottom in the form of a ball. At this stage, the vermicompost is removed to get the worms. The worms are collected for new culture beds. The vermicompost collected is dried, passed through a 3 mm sieve to recover the cocoons, young worms, and unconsumed organic material. The cocoons and young worms are used for seeding the new culture beds. The vermicompost recovered is rich in macro-nutrients, microbes such as *actinomycetes* and nitrogen fixers, and is used as manure.

By establishing vermiculture units villager can recycle their own resources and create an effective fertilizer in the process. The extra worms that are produced can be used as feed for poultry and fish. The advantages of this technology include: recycling of organic wastes; production of energy rich resources; reduction of environmental pollution; provision of job opportunities for women and jobless people; improvement of soil pH. (vermicompost acts as a buffering agent); improvement in the percolation property of clay soils (from the compost's granular nature); improvement of the water holding capacity in sandy soils; release of exchangeable and available forms of nutrients; increase of oxidizable carbon levels; improving the base exchange capacity of the soil; improvement of the nitrate and phosphate levels; encouragement of plant root system growth; improvement in the size and girth of plant stems; early and profuse plant flowering and creation of a substitute protein in poultry and fish feed.

Key words: Waste Management; Vermicomposting; Organic Farming; Earthworms

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LIMNOLOGICAL FEATURES OF PANGONG TSO - A HIGH ALTITUDE LAKE OF LADAKH, INDIA

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A limnological survey of the Pangong Lake, a land locked lake situated in eastern part of Ladakh (Indian Tibet), at an altitude of 4,266 m A.S.L., revealed that the lake is highly alkaline (pH \leq 9) with high

conductivity ($> 1500 \mu\text{S}$) as compared to its inlet stream (Cheshul stream). The mean pH of the stream fluctuated around 8 and mean Conductivity was $153 \mu\text{S}$. There is no outlet to the lake and loss of water is only through evapotranspiration. The water of the lake was very hard as compared to the stream. The usual progression of the cations in the lake was $\text{Mg}^{++} > \text{Na}^+ > \text{K}^+ > \text{Ca}^{++}$ while as in the stream the progression was $\text{Ca}^{++} > \text{Mg}^{++} > \text{Na}^+ > \text{K}^+$. Due to more solubility Magnesium content in the lake was higher than the Calcium and Sodium. The mean Chloride content of the lake and stream was 1594 mg/l and 15 mg/l respectively. Nitrate and Total Phosphorus in the lake were also comparatively higher as compared to incoming waters.

Sixteen (16) phytoplankton taxa were recorded from the lake and belonged to only four classes; the periphytic community in the stream was represented by 30 taxa and belonged to five classes. Zooplankton was recorded only from the lake and was represented only by a red coloured copepod, *Diaptomus* spp. No fish was observed in the lake while as in the Cheshul stream three fishes *Schizopygopsis stoliczkae*, *Triplophysa stolizakae* and *Triplophysa gracilis* were recorded.

Key words: Pangong Lake, Land locked, Ladakh, *Diaptomus* spp., Cheshul stream.

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BIODIVERSITY CONSERVATION VALUE OF BETEL NUT AGROFORESTS OF SOUTH MEGHALAYA, NORTH-EAST INDIA

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In south Meghalaya, tribal farmers enrich the sub-tropical moist evergreen forests with betel nut (*Areca catechu* L.) while retaining most native plants. These traditional forest gardens evolve over several years and eventually create a unique agroforestry system. Despite immense socio-economic and ecological value of these agroforests, no study is available on their plant diversity and economic importance. We investigated plant species composition of the betel nut agroforests using standard vegetation analysis research methods. We recorded a total of 160 flowering plant species, which included 83 tree species, 22 shrub species, 41 herb species and 14 climber species. These agroforests provide cash income, medicine, timber, fuel wood and other products for household consumption as well as for sale. We conclude that this traditional agroforestry system serves as home for many economically important plant species and thus contributes towards *in situ* conservation of biodiversity.

Key words: Biodiversity, NE India, Agroforestry

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BIODIVERSITY, SHIFTING AGRICULTURE AND SUSTAINABLE DEVELOPMENT IN NORTH-EASTERN INDIA

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North-Eastern Hill Region of India along with the adjoining Montane Mainland of South-East Asia (the region covering parts of Cambodia, China, Laos, Myanmar, Thailand and Vietnam) is a globally significant region for several reasons: (i) it is home to around 300 ethnic minorities with a total population of 600 million that have survived and evolved in isolation over a long period of time due to linguistic and terrain

barriers, (ii) the region is endowed with an extremely rich biodiversity due to huge variation in elevation, geomorphological features, unique biogeography and cultural diversity (iii) the region covers watersheds of international/regional rivers system (iv) high rates of migrations due to constant interventions by the government programmes. Though immensely rich in terms of natural resources, the region is marginal in terms of conventional socio-economic indicators of development such as per capita income, road density, degree of adoption of modern technologies and education level. Shifting agriculture continues to be the major land use and focal economic activity of majority of people in the region. Over the last few decades, national governments as well as international agencies have made several efforts to promote environmental conservation together with socio-economic development of local communities. However, the outcomes are far from the expectations.

The low level of effectiveness of conservation-development interventions is rooted in the gaps in scientific knowledge on ecological, economic and social dimensions of traditional land uses, livelihoods and development interventions, including: (i) coverage of a narrow range of the huge farming system diversity and hence uncertainties of generalization made about environmental/economic efficiency agricultural/forest production systems, (ii) deductions on sustainability/unsustainability of shifting agriculture or alternatives to this traditional land use based on value judgments and short-term diagnostic analysis rather than a rigorous scientific analysis, (iii) limited knowledge on modeling and relating economic and ecological processes over a range of spatial (plot scale, village landscape scale and regional landscape scale) and temporal scale (current state, present generation and future generations), (iv) lack of scientific validation of farmers' knowledge drawn from field observations and (iv) lack of a unifying research methodology to draw sustainable land use plans satisfying the needs of local communities coupled with environmental conservation to the benefit of the wider global community. International and national efforts are called for filling in these lacunae in existing knowledge.

Key words: Biodiversity, Sustainable Development, NE India