INTRODUCTION

The scenario of global biodiversity is an interesting and important matter if we wish to scrutinize the dynamics of organisms in relation to their environment. The seven continents and five oceans of the world harbour innumerable life forms. The most fascinating aspect is that the floral and faunal wealth is distributed divergently or convergently in different parts of the world, influenced by factors ranging from geological connotations, climatic changes, biotic/abiotic stresses to recent environmental changes. Asia among the seven continents is largest in the world in its area (30% of world's land area) and harbors five megadiversity countries viz. China, India, Indonesia, Malaysia and Philippines. Among the biodiversity hotspots recognized in the world, four viz. Himalaya, Indo-Burma, western Ghats along with Sri Lanka and Sundaland (including Andaman & Nicobar Islands) lie in the Indian subcontinent, making it coveted hub for biodiversity explorations.

Biodiversity and its importance in Indian context:

India is endowed with a strategic geographical position, three sides surrounded by water bodies and one side by highest mountains of the world. With such an enviable geographical location, the varied climatic conditions and rich vegetational attributes are an obvious feature of India and surrounding regions that together form the Indian subcontinent. The huge biodiversity that lies enfolded in vegetationally rich areas of India poses a challenge to the researchers to unveil its wealth. The fact that India occupies merely 2% of the world’s land area but harbours 10-11% of the total biodiversity, prevailing world wide is an advantageous heritage of nature and boon for biologists. The Indian region has been divided broadly into eight geographical zones for the convenience of study and assessment of phyto-diversity. The broad divisions include – the western Himalaya, eastern Himalaya, Gangetic plains, central India, Eastern Ghats, Western Ghats and Andaman and Nicobar Islands. Among these, the eastern Himalaya and Western Ghats are exceptionally rich regions and therefore celebrated worldwide for their biotic wealth.

Biodiversity simply refers to the diversity and existence of life forms (all types of living organisms) when considered in respect to their environment or surroundings. It is a broad term that explains the dynamics of biotic and abiotic factors and the
synchrony of their existence on the earth. The latter half of the past century witnessed a rapid increase in the awareness of mankind towards the biodiversity prevailing on our planet, its knowledge, utilization, conservation and sustainable development. The early 20th century had decades of turmoils and uncertainties that surfaced from the disagreements among global nations and traumatic world wars. When at last stabilization and peace prevailed, apparently, if not actually, the focus of mankind shifted to their natural wealth may it be the minerals, oils, forests, fauna and flora or oceanic resources. The alarming depletion and destruction of natural resources forced the environmentalists and biologists to initiate flagship projects that would help in sustaining if not reversing the natural resources.

The civilizations that have existed and evolved in the history of human race were not totally ignorant of the nature, its use and conservation. In fact the previous human races exercised different means to nurture and replenish natural resources and environmental imbalances caused by human activities. Shifting agriculture, nomadic lifestyle and eco-friendly town constructions are a few instances of such practices. The societal beliefs of associating natural calamities and disaster to human ill deeds are also methods used in the past civilizations to make people aware and considerate towards their environment. Coming closer for example, even in our Indian society the most primitive human settlements are known to worship natural forces such as rain, thunder, sun, sky, fire etc. as deities and gods. Even to this day, the bargad (banyan) tree (Ficus bengalensis), the Peepal tree (Ficus religiosa) and the Tulsi (Ocimum sanctum) are considered related to divine forces. Further, associating wild animals to dieties such as considering Cow, Elephant, Bull, Lion, Tiger, Rodents, Snakes and many other animals as sacred or associated to some hindu god, only led to the society being aware and not harming these uselessly. These are the examples of how the society was made aware of benefits of conserving flora and fauna.

- **Scenario of biodiversity conservation in Indian context:**

  In the modern world since the toil to modernize and develop seems unending, simple measures are dwarf in comparison to the mammoth need of conserving the natural wealth. The world came together for such efforts and inception of the Convention on Biological Diversity in the year 1993. However, more than two decades before this Convention, considering the urgent need to protect flora and found, united
Nation’s environment protection body UNESCO (United Nations Education Scientific and Cultural Organization) had initiated a world-level program called the Man and Biosphere (MAB) Programme in 1971 and introduced the concept of Biosphere Reserves. Although protected areas such as National Parks and Wildlife Sanctuaries were previously present in countries including India, yet the Biosphere Reserve includes a much wider aspect being a conservation unit where natural existence of biotic resources converges with the sustainable human activities resulting in a natural but harmonious existence of man and his natural wealth. A Biosphere Reserve has three zones:

i) Protected zone (core zone) where the human interference or activity is prohibited in the area without permission of authorities

ii) Managed use area (Buffer Zone) where limited activity is observed

iii) Zone of co-operation (Transition Zone) where human settlements are allowed and sustainable activities are encouraged.

Considering the presence of ample biologically diverse regions in India, developing a protected area network is a major step taken by the Government to conserve the Indian Biodiversity. India therefore boasts of nearly 166 National Parks, 515 Wildlife Sanctuaries (41 among these are Tiger Reserves) and 18 Biosphere Reserves. Among these Biosphere Reserves, 7 have been included in the UNESCO’s Man & Biosphere (MAB) Programme. Pachmarhi Biosphere Reserve (PBR) lying in the Hoshangabad, Betul and Chhindwara Districts of Madhya Pradesh is the 8th largest Biosphere Reserve in terms of area among the total 18 in India. It was designated under MAB Programme in 1999. With an area of 4987.38 km squares, PBR encompasses three conservation units viz. the Pachmarhi Sanctuary, Satpura National Park and Bori Sanctuary along with the areas surrounding these. The inclusion of three conserved sections in the Biosphere Reserve increases its importance as all the floral and faunal diversity otherwise under three units is now consolidated under single conservation unit which will definitely be more rich and dense in terms of biodiversity. Added to this, the Satpura National Park was undertaken into the National Project- 'Project Tiger' since the year 2000, and now popularly known as the Satpura Tiger Reserve. PBR is the most prominent Biosphere Reserve among the protected areas of central India and the rich biodiversity present here obviously tempts the zoologists, botanists and environmentalists to unveil this diversity.
• **Importance of Study area- Pachmarhi Biosphere Reserve:**

Among the bryogeographical zones of India, PBR falls under the central Indian zone. The importance of this region is that the central Indian belt, specially the Satpura Mountain range forms the connecting link between the diversity of eastern Himalaya and South Indian region specially the Western Ghats. These two regions are the important hotspots of biodiversity and their connecting region thus holds evolutionary importance. Further, the Satpura hills correspond to the Gondwanalandic formations of past. The primitive single land mass Gondwanaland disintegrated during the continental drift and resulted in scattered segments that moved away from each other. Consequently, the remnants of Gondwanaland are present in many regions of the world. In India the Satpura hills and the Narmada basin are the main portions of Gondwanalandic origin. The sedimentary rocks and mildly alkaline calcareous soils Tripathi et al (2009) at PBR are examples of Gondwanalandic lineage.

Apart from the geological significance PBR was celebrated as a sanatorium since the British rule in India. As long as 150 years ago the region was first time noticed by a British officer Captain J. Forsyth and his recommendation led to the establishment of Pachmarhi and nearby localities as a summer retreat of the Britishers. After Independence, the area was made accessible to the civilians and developed as a tourist destination. It has been long since the scenic, vegetational and cultural aspects and their importance was recognized by the State and Centre. The inclusion of three units of the region viz. Pachmarhi Sanctuary, Satpura National Park and Bori Sanctuary under the Wildlife Protection Act suggests the importance of this area. The vegetational aspects of PBR are recognized by geologists and life science experts but what makes the place specially noticeable is that the cryptogamic (lower plant) flora of the region viz. the pteridophytes, bryophytes, lichens and algae share a major portion of biodiversity of the region. Amid the cryptogams, Pteridophytes and Bryophytes form the greater share of representation with nearly 94 pterophytic taxa (Singh & Kaul 2002) and 130 liverworts (Handoo et al. 2009, Sharma and Alam 2011) known so far.

As far as the cryptogamic flora of PBR is concerned, researchers have ventured into the studies of algae, lichens, bryophytes and pteriodophytes from later part of the 20th century. Some noteworthy accounts are those of Agarker and Agarkar (1977) for algae, Muthukumar and Tarar (2000, 2000a) for lichens and Bir and Vasudeva (1992, 1973), Vasudeva & Bir (1992, 1993), Vasudeva (1995), Singh et al (2009), Singh &

- **Importance of species composition and diversity of bryophytes:**

  The evaluation of bryoflora in terms of ecological aspects such as habitat distribution, landscape type and altitude distribution is very significant to obtain a complete overview of bryophyte diversity. The distributional aspects of bryoflora of any region (PBR here) could be explained more exactly with a proper data pertaining to the ecological affinities of plants at the said region.

  Although bryophytes show wider geographic ranges than other terrestrial plants (Groombridge 1992), still the bryophyte distribution in general and at any region in particular depends upon some important factors such as availability of water and suitable conditions of growth (Schofield 1992). The important ecological aspects of bryophytes have been taken up by workers such as Richards (1984), and Gradstein and Pocs (1989) who argued that bryophytes prefer shady places and dense cover for growth and that damp conditions along with higher light levels favour the growth of epiphytic and terrestrial bryophytes. Further, the light conditions and landscape features control bryophyte diversity and rarity at a regional level. This hypothesis was greatly aided by Vanderpoorten & Engels (2003).

  Ecologically, bryophytes and lichen have striking similarities, both groups being poikilohydric and of small stature with predominance of asexual reproduction, (During, 1992) Further, since lichens behave as ectohydric bryophytes (Longton 1988) similar ecological treatment of both groups is a natural aspect of study.
As the Biosphere Reserves and conserved units possess protected and sustained environment and therefore, the ecological characteristics of such a unit tend to be evolving naturally with little or insignificant disturbances caused by human activities. However, the core zone remains well protected whereas the buffer and transition zones tend to be affected by anthropogenic factors. To assess the bryophyte distribution patterns at a protected area, it is imperative to take into account the various ecological factors prevailing there. The landscapes, habitats and climatic factors together account for the trends observed in the bryophyte diversity. The study areas encompasses ravines, valleys, gorges, plateaus, hills, perennial streams and stretches of bare rocks that offer exquisite variety of habitats and scope of a thorough assessment.

The bryophytes show different growth and morphological forms. Giesenhagen (1910) was first to describe growth form types of bryophytes. The growth forms hold importance in diversity assessment as these correspond to competition and abiotic environmental conditions, notably water relations (Gimingham and Smith 1971, Mägdefrau, 1982) and can be seen as the adaptation of plant to their environment. Moreover, four morphological forms of bryophytes viz. thalloid and leafy (in case of liverworts and hornworts) and acrocarpous and pleurocarpous (in case of mosses) have significance as these forms have role in explaining plant – habitat relationships and ascertain the probable distribution at an area. The quantitative studies of bryophyte vegetation is important aspect in assessing the diversity at any area, some noteworthy accounts in this respect being those of Bates (1982) and Krebs (1989).

- **The purpose of present study:**

  As mentioned above, scattered accounts of the bryoflora of PBR were present but a consolidated account of the bryophyte diversity of this area remains lacking. The scattered accounts although add to the knowledge of bryophytes of this region, yet a crystal clear picture of the species composition, distributional pattern and bryophyte diversity prevailing at PBR is wanting. Hence the present work has been carried out with the following objectives:

  - An assessment of diversity of the bryophyte flora of the region with special reference to the species and generic diversity, along with performing gradient analysis.
The assessment of the species richness or 'within habitat diversity' and community richness or 'between habitat diversity' and a total of both, expressing the landscape's total diversity.

The detailed study with reference to the distribution pattern, abundance, meagerness, paucity, dominance and the frequency of occurrence of the various taxa will be performed.

SEM studies of the spores, leaf surfaces and peristome which aid the taxonomic treatments and explanations will be undertaken.

The rare, endangered and endemic bryophyte taxa if present at the area undertaken for study will be assessed.

Preparation of illustrated taxonomic account of the bryophytes of proposed area along with distributional maps.

The introductory chapter (Chapter I) deals with the aims, objectives and importance of the proposed work. The second chapter (Review of Literature) summarizes the important and noteworthy accounts on bryophyte taxonomy and ecology by past and present workers, outlining the contextual importance of present work. The third chapter describes the layout of the study area- the study site characteristics, climate, geology, vegetation and physical characteristics of the habitats selected. The fourth chapter deals with the materials and methods undertaken to perform the taxonomic analysis and assess the species composition and habitat diversity of the bryoflora. The fifth chapter deals with the detailed taxonomic studies of bryophytes giving illustrated accounts of the identified taxa. Chapter VI provides the assessment of species composition and diversity of bryophytes across different habitats in the sites of three different altitudinal gradients. The seventh chapter deals with general discussion where significant results have been discussed with relevant references and interpretations. Finally the references and summary have been provided. The present account promises to add to the knowledge of the bryophyte diversity prevailing at the region.
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