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Biodiversity Monitoring and its Distribution in and Around Uranium Mining Area of Gogi, Gulbarga (Yadgir), Karnataka: A Case Study

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ABSTRACT Uranium is available in Gogi, Gulbarga District (now Yadgir), Karnataka. The area spreads over 30 km from the central point of the potential Uranium site to be mined for sustainable energy production. A field study was conducted across different zones of the region for different seasons. With the help of a phytosociological study, 376 species of angiosperms (trees, shrubs, herbs and climbers), 1 bryophyte, 4 pteridophytes, 5 lichens and 20 phytoplankton have been recorded. The number of bryophytes and pteridophytes species recorded is low as the geo-climatic conditions of the area are not suitable for those species. This study did not report any gymnosperm from the natural landscape excepting cultivated lands. From the study are 164 species of insects, 82 species of spiders 17 mollusks, 11 fishes, 5 amphibians, 13 reptiles, 71 aves, 11 mammals and 24 zooplankton were recorded following standard protocol developed for conducting the current study. Varieties of butterflies have been spotted in and around the study zones. The aim of the current study is to provide baseline information on the biodiversity of the proposed uranium mining area for a better understanding of the availability and distribution of flora and fauna across the area.

INTRODUCTION

Biodiversity is an important constituent of the sustainable landscape development thus an important ecological, economic, and social/cultural resource that gives the basis for the sustainability of any region. Species richness has, in general, a positive effect on the quality of the ecosystems (Brabyn 2005; Nautiyal 2011). The conservation of biodiversity and its management require accurate information about extent and spatial distribution of individual species in nature (Lu et al. 2004; Navaneethan et al. 2011). For qualitative and quantitative information on biodiversity the data pertaining to each species is important to collect. The big concern in the landscape dominated by human being is that how society and ecosystem interaction takes places for resource conservation, use and management (Liu 2001). To understand the human influence on the landscape there is a need for developing detailed database on existing biodiversity. The research endeavors in this regard provide baseline information that would help in understanding the impact of developmental processes on the biodiversity and bioresource flow. The processes of development have broadened to include biodiversity monitoring and mapping as stepping stone that help in maintenance and restoration of ecological systems (Wallace et al. 1996). The study on qualitative and quantitative aspects of biodiversity is basic key to understand the ecosystem functioning and hence provide the basis for designing and developing the strategies for impending sustainable socio-ecological development (Singh and Singh 1992; Bisht 2013; Maikhuri et al. 2013). This study provides the detailed information on biodiversity of Uranium mining area of Gogi, Gulbarga (Yadgir), Karnataka. The objectives of the study were to study the different vegetation strata (that is, tree, shrubs, herbs, grasses, tree saplings, seedlings) across the zones of the study region and to explore, survey and document the fauna (above ground and below ground); and to document traditional knowledge related to use, conservation and management of biodiversity in the study region.

Study Area and Climate Pattern

The study region located in Yadgir and Gulbarga Districts in North Karnataka, spreads over a 30 km radius from the centre point Gogi (2826 km^2). The area is located 17.33°N 76.83°E with an average elevation of the 455m (1492 ft.) above sea level (Fig. 1). The area is endowed

with 2 rivers and 11 major lakes, comes under Deccan Plateau and is mostly covered by dry deciduous vegetation. Adjacent to Gogi, particularly in Shahapur and Surpur *Taluks,* some parts are covered with hillocks with barren and stony surroundings while other villages are covered with sparse natural vegetation. According the map-soil orders of Karnataka State, the soil system of the study area is mainly composed of entisols, vertisols and inceptisols.

Climatically, the study region is a very hot and arid with low rainfall and high temperatures and experiences mainly 3 seasons - the summer from late February to mid-June, followed by the south- west monsoon from the late June to late September, and dry winter until mid-January. The study region is a drought prone area with an average rainfall of less than 650 mm spread over 46 rainy days in a year. The weather is very hot during summer with day temperatures hovering between 26°C in winter and 42°C in summer.

METHODOLOGY

For undertaking an in-depth eco-diversity study, the entire area has been divided into three zones - 0-5km Core Zone and henceforth "CZ"; 5-15 km Buffer Zone I, "BZ-I"; and 15-30 km radius, Buffer Zone II, "BZ-II" based on Survey of India toposheets and Arc GIS software. The core zone surrounds the area where mining takes place. In the CZ, there are 7 villages out of which two villages are uninhabited. The entire CZ, was covered for conducting an extensive study, while the buffer zones, BZ- I and BZ- II were divided into 16 sectors each. Various sampling methods *viz*., random, systematic, stratified were used for the study from each sector.

For an in-depth study of plant biodiversity

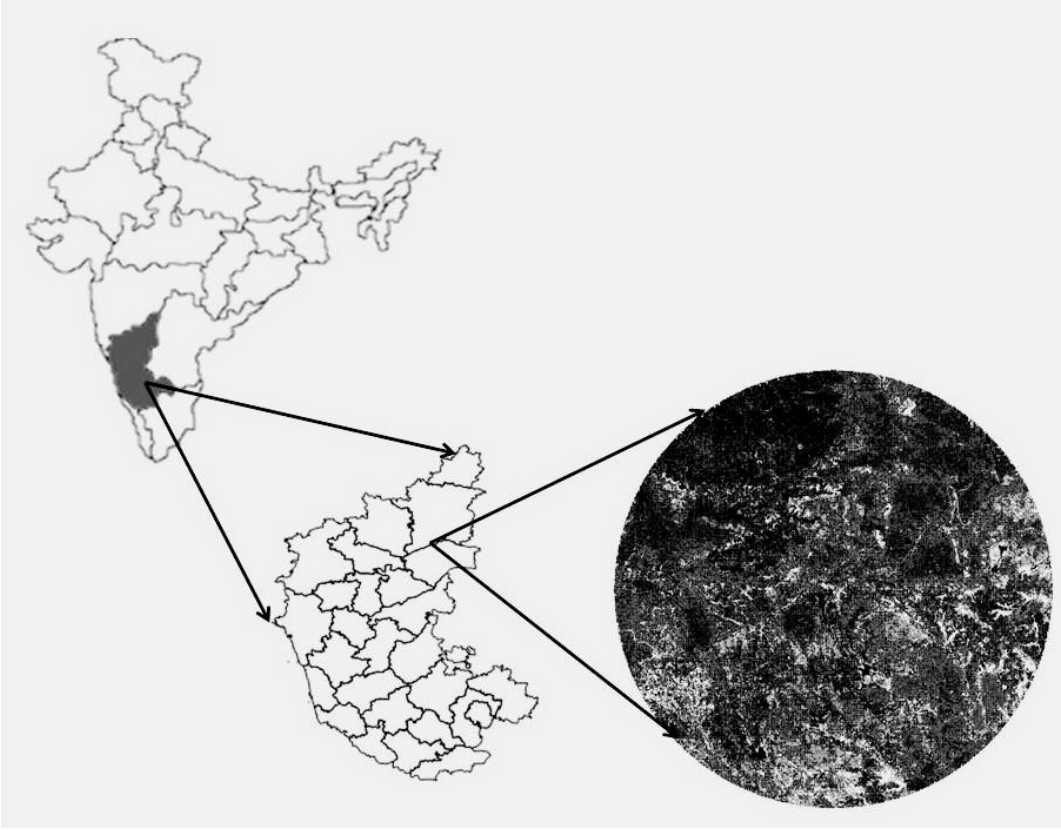

Fig. 1. Location of study area in Karnataka, India

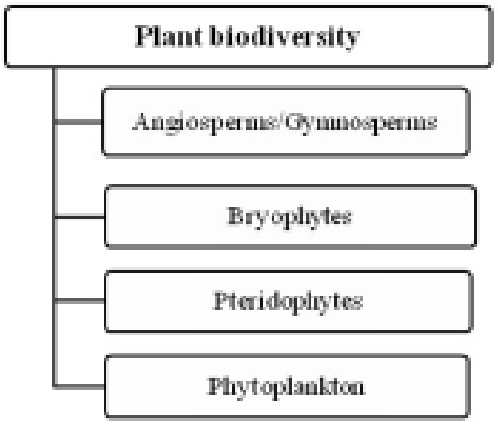

Fig. 2. Flow chart showing the plant biodiversity study undertaken in the study region

the researchers have followed the standard methods (Cottam and Curtis (1956), Curtis (1959), MacArthur (1965), Whittakur (1975), Saxena and Singh (1982), Phillips (1959), Nautiyal and Kaechele (2007, 2008). The researchers have studied the plant biodiversity as given in Figure 2.

To study the faunal biodiversity, the researchers have followed the standard methods (Enmondson 1959; Gaston 1973; Bouche 1977; Thomas 1990; Meyer 1996; APHA 1998; Grimmet et al. 1998; Trigunayat 2002; Chanda 2002; Sathe et al. 2005; Daniels 2005) (Fig. 3).

To study invertebrates, line transects of variable lengths, light traps, pit fall traps, baited traps and litter collection methods were used. Also an avian diversity study was done by using line transect and point count methods. Data on big mammals was recorded by sound observations and an analysis of pug marks, scats, pellets and vocal. Fish species were surveyed and identified by net fishing in major water bodies and exploring the fish markets. A belowground biodiversity study was also carried out. Litter samples were collected from the field without disturbing the central part 10X10cm grid of the different land ecosystems and transferred to the Berlese Funnel for further cleaning and extraction of samples.

All the collected plant species were preserved in herbarium sheets in triplicates, prepared, using standard formats, developed by Botanical Survey of India, while invertebrates and fish species collected were preserved either dry or wet for identification and for preservation. Plant parts like bark, root, leaves and fruits were also collected and preserved in the laboratory. Quantitative data on each species are described in detail. A survey using a structured questionnaire was conducted among the selected villagers of the region for gathering and documenting the knowledge regarding the traditional use, conservation and management of flora and fauna in the study area. The study was undertaken in different zones of the region across different seasons spread over a duration of 2 years. A phytoplankton sampling was done randomly in 20 localities with 4 lakes using Phytoplankton nets. The methods used in this study for exploring, surveying, collecting, preserving and identifying various species conform to the protocols of Board of Research in Nuclear Sciences, Department of atomic Energy, Govt. of India.

The data collected on both floral and faunal diversity was tabulated and used for an analysis of Density, Abundance and Frequency, Importance Value Indices (IVI). A further quantitative data analysis was carried out with respect to various aspects by generating diversity indices like- Shannon-Wiener Index, Beta Diversity, Concentration of Dominance (Cd) and Simpson Reciprocal Index for different vegetation strata.

RESULTS AND DISCUSSION

Through a phytosociological study in CZ, BZ-I and BZ-II of the study area, 376 species of Angiosperms (Trees, Shrubs, Herbs and Climbers), 1 Bryophyte, 4 Pteridophytes and 5 Lichens have been recorded. The number of bryophytes and pteridophytes species recorded is low as geoclimatic conditions of the area are not suitable to those species. No gymnosperm has been reported in the study area excepting gardens. Species richness in the area is dominated by the following families, that is, Euphorbiaceae (21), Fabaceae (21), Mimosaceae (19), Asteraceae (16), Asclepiadaceae (13), Convolvulaceae (13), Acanthaceae (11), Amaranthaceae (11), Caesalpiniaceae (10) and Verbenaceae (9). The total species in the CZ, BZ I and BZ II number 174, 206 and 209 respectively with unique code numbers given to all the species collected from all the three zones. Plant biodiversity in this region is sparse and trees grow to a limited height, a typical arid zone characteristic.

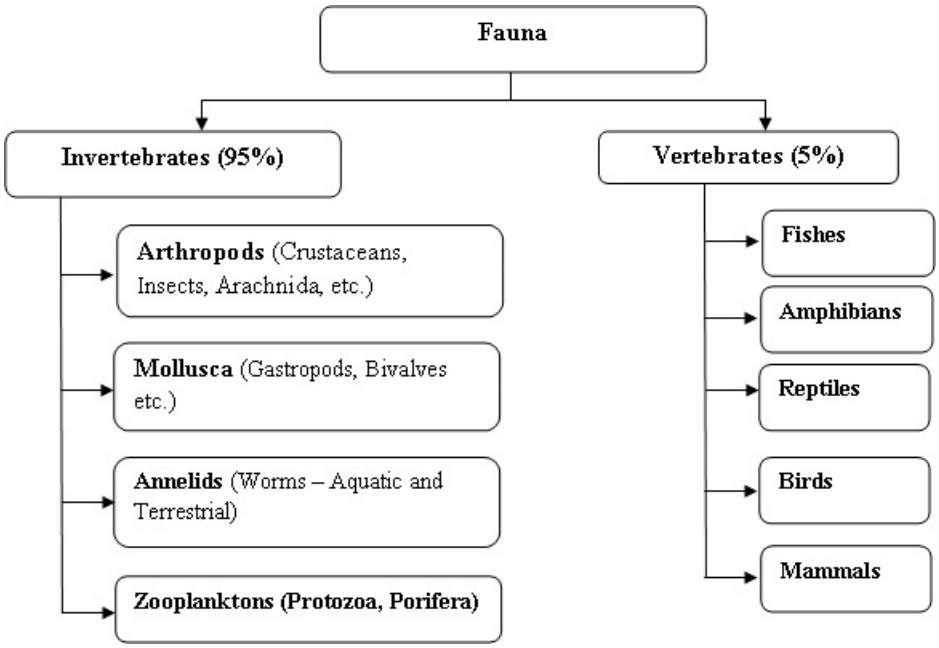

Fig. 3. Flow chart showing the faunal study undertaken in the study region

From the CZ The researchers have recorded 30 species of trees, 39 shrubs, 66 herbs, 34 climbers belonging to 55 families of the plant kingdom. The top ten dominant families in the CZ are Fabaceae (16), Euphorbiaceae (13), Convolvulaceae (11), Asclepiadaceae (10), Mimosaceae (10), Amaranthaceae (7), Asteraceae (7), Malvaceae (7), Caesalpiniaceae (6) and Verbenaceae (6).Among 30 tree species found in the CZ, the most dominant tree species are *Prosopis juliflora* with IVI of 104.93, followed by *Azadirachta indica* with IVI of 70.12. This species is also dominant in the other two zones with IVI of 95.3 and 46.2. Although *Lantana camara* is a dominant shrub species in the CZ and the other two zones, it is in the CZ that *Lantana camara* is highly dominate with IVI of 93.8.

A total of 51 species of trees, 44 shrubs, 103 herbs, 35 climbers, 7 hydrophytes, 1 bryophyte, 2 pteridophytes were found in the BZ-I. These species belong to 71 families of the plant kingdom. The top ten dominant families in the BZ-I are Euphorbiaceae (15), Mimosaceae (15), Asclepiadaceae (12), Fabaceae (12), Amaranthaceae (9), Asteraceae (9), Caesalpinaceae (9), Acanthaceae (7), Convolvulaceae (7) and Malvaceae (7).

In the BZ-II, the researchers have found 57 species of trees, 40 shrubs, 95 herbs, 30 climbers and 8 hydrophytes which belong to 66 families of the plant kingdom. The top ten dominant families in this zone are Euphorbiaceae (21), Fabaceae (21), Mimosaceae (19), Asteraceae (16), Asclepiadaceae (13), Convolvulaceae (13), Acanthaceae (11), Amaranthaceae (11), Caesalpinaceae (10) and Verbenaceae (9).

Phenological data has been recorded for tree and shrubs species in the study region. The forested area of Gogi region comes under the dry deciduous type; leaf-fall of most of the tree species coincides with the dry season (November to February), while budding and leaf-flushing from March through to April. A majority of plant species have been observed with regard to their flowering and fruit bearing during the year. The field observations reveal that 4 species were flower throughout the year, while seven tree species for 7 months at different times of the year. Some of the species flower only for a period of two months.

The study area nurtures many plant species, with a substantial economic value and traditional use for meeting the needs of local people in the forms of timber wood (9 species), edible fruits

(18 species), fuel wood (26 species), fodder (23 species), oral hygiene (11 species) among others. The timber requirements are satisfied by tree species like- *Tectona grandis, Azadirachta indica* and *Bauhinia racemosa* which are found in the agricultural lands and villages of Gogi. Domestic fuel demand is met by the use of fuel plants like- *Prosopis juliflora, Balanites egyptiaca, Casuarina equisetifolia, Lantana camera* etc. A glimpse of various species found in the study area across sectors is given in Figure 4.

Other than these plants with traditional and economic values, there are 80 species of medicinal plants which are useful in curing 19 ailments like cold and cough, bone fracture/pain, jaundice, diabetes etc. The uses and the mode of preparation of medicines have been recorded and documented accordingly. Santalum album and Acacia ferruginea in the study area are found listed in the Red Data Book of IUCN in view of their being vulnerable (http://www.iucnredlist.org/).

Variability in diversity across ecosystems or habitats is known as beta diversity (β-diversity). Of the three zones studied, trees show a high β -diversity value (2.4) for the CZ. The same is observed for shrubs and herbs with β-diversity values 1.56 and 2.25 respectively. The Shannon-Wiener Index (H-) derived for all the three zones estimates the species diversity within a given area. The H- values are in the range of 0.36 to 1.44 for the CZ; 0.39 to 1.56 for BZ-I and 0.20 to 0.87 for BZ-II.

The faunal diversity study includes classes- Fishes, Amphibians, Reptiles, Aves and Mammals under vertebrates and Arthropoda, Mollusca and Annelida under invertebrates; butterflies and dragonflies have been studied extensively. The screenshot of the studied fauna is depicted in Figure 5.

Around 164 insect species belonging to 13 orders and 67 families have been collected, identified and documented for the three different zones. A detailed quantitative analysis has been carried out for the faunal species. Out of the total species, 39 are found in all the three zones. However, all the CZ species are found in the other two zones as well. CZ and BZ-I support 13 species common among them whereas, 52 species are common to BZ-I and BZ-II and 37 species are common to BZ-I and BZ-II. BZ-I and BZ-II are home to 14 and 9 unique species respectively.

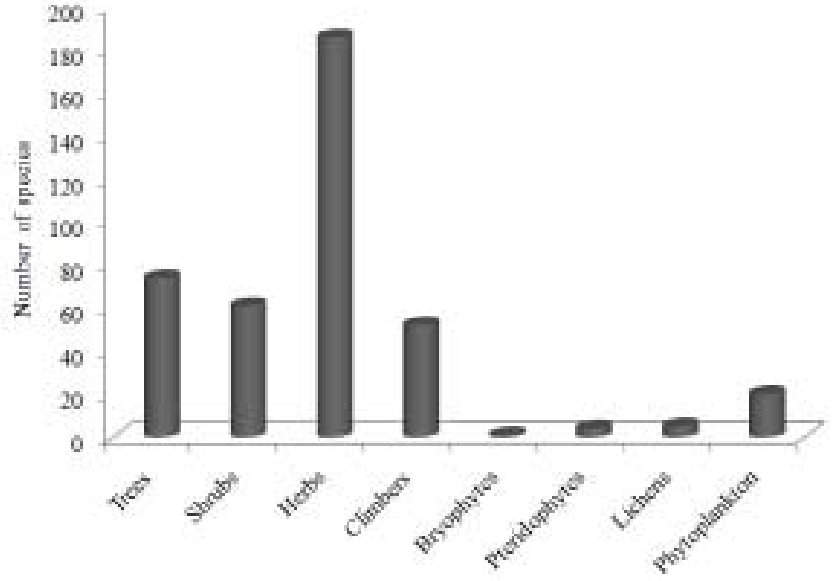

Fig. 4. Plant biodiversity of the study area

A total of 28 butterfly species belonging to 6 families of order Lepidoptera have been recorded for the entire study area. The family Nymphalidae, represented by 13 species (46.43% of the total butterfly species) is the most dominant one followed by Papilionidae (21.43%) with 6 species, Pieridae (17.86%) with 5 species, Lycaenidae (7.14%) with 2 species, Satyridae and Hesperidae (3.57%) with 1 species each. In CZ, only three families namely Nymphalidae, Papilionidae, and Pieridae are found. In BZ-I 4 families are found which include Satyridae along with the above mentioned 3 families. BZ-II nurtures 6 families which include Hesperidae and Lycaenidae together along with the ones mentioned above.

Seasonal appearances of butterflies have also been studied for different species for different seasons; it is observed that Blue pansy (*Junonia orithya*) and Peacock pansy (*Junonia almana*) appear during two seasons, that is, June to August and Dec to February. Of the 28 species of butterflies observed in the study area, although the maximum numbers of butterflies are seen during the months of September to February, their number peaks during December and January. The least number of butterflies are seen during the months of March to May.

In CZ, a total of 7 species of butterflies belonging to three families have been collected and documented. Butterfly species in CZ are represented by Nymphalidae (4 species), Papilionidae (1 species) and Pieridae (2 species). The most abundant butterfly species spotted in the zone happens to be Plain tiger (*Danaus chrysippus)*, while Danaid egg fly (*Hypolimnas misippus)* is the least abundant one. In BZ-I, 24 species of butterflies belonging to 4 families have been identified with Nymphalidae being the dominant family with 12 species. In BZ-II, 28 butterfly species belonging to seven families have been collected. Again in BZ-II, the dominant family is found to be Nymphalidae with 13 species.

In CZ, 7 species of dragonflies belonging to 4 families have been collected and documented. The most abundant species identified in this zone is *Crocothemis servilia* (Ruddy marsh skimmer). BZ-I fosters 10 species of dragonflies belonging to 4 families. The most abundant species identified is Rusty Darner (*Anaciaeschna jaspidea*), while the least abun-

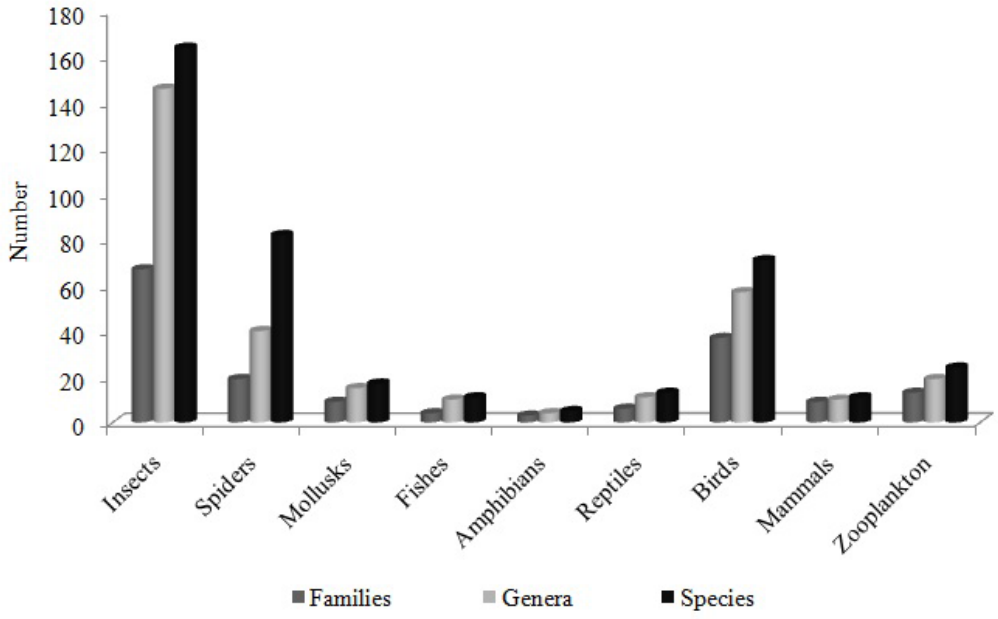

Fig. 5. Faunal diversity of the study region

dant species is Blue-tailed Green Darner (*Anax guttatus)*. In BZ-II, 13 species of Dragonflies belonging to 4 different families have been collected and documented. The most abundant species identified is Ruddy Marsh Skimmer (Male) (*Crocothemis servilia*), while the least abundant species is Wandering Glider (*Pantala flavescens).*

A total of 82 spider species (individuals including males, females and juveniles) have been collected from different types of habitats. In addition to this, 5 species show new characteristics; identification and nomenclature process of these species is in progress. All these species belong to 19 families of the order Araneae in class Arachnida.

The Phylum Mollusca represented by 17 different species, which has been collected from Krishna and Bheema Rivers and some tanks of the Gogi study area. These 17 specimens collected belong to 9 families.

Belowground biodiversity has been studied across different habitats like agricultural fields and grasslands during monsoon (June-July) and post monsoon (August-September) seasons though with more species being collected during post monsoon (19 species) in comparison to monsoon (13 species) period. Among those species, 9 species are common to both the seasons with most of these species belonging to Phyla Arthropoda and Annelida.

The total vertebrate species surveyed and listed in the entire study area 111 belonging to different phyla: Fishes (11), Amphibians (5), Reptiles (13), Aves (71) and Mammals (11); 11 fish species found in the study area belong to 4 different families viz.- Channidae, Cichlidae, Cyprinidae, and Siluridae. The most commonly found fishes are from the family Cyprinidae across all the three zones. Among those 11 species, 6 are to be found only in rivers while the rest 5 in rivers and lakes. The least number of species are found represented by amphibians, which is anticipated given the arid geographical region. The 5 amphibian species belong to three families *viz*., Bufonidae, Ranidae, Rhacophoridae. In CZ we did not find common Indian tree frog (*Polypedates maculates*). All 13 species of reptiles belong to order Squamata of 6 different families. The species found in abundance include house gecko, keeled Indian mabuya and Indian monitor lizard. All the reptiles found in CZ and BZ- I are also found in BZ- II. Aves, the most prevalent vertebrate in the region is represented by 71 species of which 15, 31 and 4 species are identified to be aquatic, terrestrial and both aquatic and terrestrial respectively. The most abundant species belonging to the family Ardeidea is represented by 6 species (5 aquatic and 1 terrestrial). In and around 5 villages in the CZ, 32 species of birds have been identified with white breasted kingfisher being the most abundant species among them. BZ-I harbours 54 species while BZ-II 59 species of birds; Lesser Paid Kingfisher and Common Myna are the most abundant bird species in these two zones respectively. Among all the vertebrates, avian species have a higher density. The region is home to 7 migratory birds; 5 of which visit during April to September, when there is a considerable amount of rain (29mm to 142mm). The study area is a habitat for 11 species if mammals belonging to 9 different families. All the CZ species (6) are found in BZ-I and BZ-II as well.

In the entire study area of 30km radius, there are only 4 notified reserve forests; these are Mahmmadapur, Naganattigi, Talwaragera, Deveragonal located in Shahapur taluk. The local communities access the reserved forests for fuel wood. Vegetation cover in the natural forested land is very sparse, and dominated by *Prosopis juliflora* (Sarkara Jalley). This species is occasionally associated with *Acacia nilotica (*Kari jali) and *Zizupus jujuba*.

Through a baseline study of flora and fauna at the proposed uranium mining site at Gogi, Gulbarga (Yadgir) district, Karnataka, the researchers have recorded 376 species of Angiosperms (Trees, Shrubs, Herbs and Climbers), 1 Bryophyte, 4 Pteridophytes, 5 Lichens and 20 phytoplankton. The number of Bryophytes and Pteridophytes species recorded is low as eco-climatic conditions of the area are not suitable to those species. No gymnosperm has been reported in the study area.

The aim of the study is to provide a baseline information as available today with respect to the impact of to future developmental activities on biodiversity in the Uranium mining area of India. The recorded biodiversity of the area includes about 760 species of plants and animals as elaborated in the previous section of the study. Of the identified species, no species is endemic to the study region. The biodiversity of the region exhibits somewhat typical characteristics

of any semi-arid climatic zone of the country. The floral and faunal species found are common species, which are also abundant in other areas. However, 2 plant species viz., *Santalum album, Acacia ferruginea* are found in the category of vulnerable under the red list of IUCN. But as this has been mentioned before, these species are also available in the surrounding areas (beyond 30kms) and other semi-arid conditions of Karnataka; thus, their multiplication and regeneration could be easily done in other areas of the regions having similar topographic and climatic conditions. However, there could be adverse impacts on the environment of the area due to various anthropogenic activities. The following measures can be adopted for managing or overcoming the adverse impacts on biodiversity. An ex-situ conservation of biodiversity is recommended, if directly affected by any human activity. A proper area with suitable environmental parameters should be identified and methods for management developed as part of an environmental Management Plan. Afforestation Plan and Command Area Development Plan should be formulated following due procedures to ensure a sustainable landscape development. A special care should be taken to conserve the economically and medicinally valuable plants which are of significant importance to the local people. A proper reclamation of soil systems should be done and ecosystem rehabilitation practiced using only local plant species. An assessment of biodiversity should be done periodically to evaluate the status of bio-diversity of the study area. Agroforestry concept needs to be diffused among the people of the region as this helps provide an opportunity to harvest the annuals with perennials from the same unit of land. Agroforestry is an old concept in that in different parts of the country, agroforestry (different sub terms) systems have been developed by the people/ traditional societies through their own indigenous ecological knowledge base (which is passed on through generations) for maximizing the output from a unit of land. A sustainable land use and land cover is one of the most important issues that suffers as a result of deforestation. Therefore, in the current context, all agroforestry systems have positive effects upon land, water and resource management. Agroforestry development has a potential applicability to improve land use and biophysical properties of lands on the one hand, and to provide an opportunity for fulfilling the daily needs of rural populace on the other. To tackle any probable future environmental contamination, bio-accumulating plant species can be planted for phyto-remediation, specifically heavy metals. The study results reveal that 12 species of bio-accumulators are available in the study area.

CONCLUSION

The study undertaken in the entire area of 30km radius has examined both the plant and animal diversity of the area besides coming out with a pre-project baseline biodiversity scenario. Of the identified species, no species is endemic to the study region. The biodiversity of the region exhibits somewhat typical characteristics of any semi-arid climatic zone of the country. The floral and faunal species are common species, which are also abundant in other areas. However, two plant species viz., *Santalum album, Acacia ferruginea* are reported vulnerable as per IUCN Red List of Threatened Species. For conservation of biodiversity and sustainable ecosystem development, following measures are suggested for managing the adverse impacts on biodiversity.

1. An ex-situ conservation of biodiversity is recommended, if directly affected by any human activity. A proper area with suitable environmental parameters should be identified and methods for management developed as part of an Environmental Management Plan.
2. Afforestation Plan and Command Area Development Plan should be formulated following due procedures to ensure a sustainable landscape development.
3. The possible loss of seed bank from the top soil should be compensated for in the nearby suitable areas for regeneration of vulnerable species, preferably in the buffer zones of the study region.
4. A special care should be taken to conserve the economically and medicinally valuable plants which are of significant importance to the local people.
5. A proper reclamation of soil should be done and ecosystem rehabilitation practised using only local plant species.
6. An assessment of biodiversity should be

done periodically to evaluate the state of bio-diversity of the study area.

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