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RHIZOSPHERIC AND NON RHIZOSPHERIC SOILS OF GOREWADA FOREST- A CASE STUDY

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Abstract:
Study of Gorewada forest was carried out to find out physicochemical as well as microbiological properties of soil collected from the rhizosphere of different plant species. Studies have shown that the forest is of dry deciduous type having trees, shrubs, herbs, climbers and grasses and some barren patches of land. Rhizospheric soil of the different plant species had clayey texture, porosity and water holding capacity was high. The electrical conductivity, organic carbon and cation exchange capacity of pit soil was somewhat high compared to barren soil; however levels of these chemical properties were lower as compared to the rhizospheric soil samples of dominant plant species. Total and available nutrient content was also high in rhizospheric soil. The bacteria, fungi, actinomycetes and nitrogen fixers viz. *Rhizobium* and *Azotobacter* and vesicular arbuscular mycorrhizae (VAM) spore counts were high in pit soil as compared to barren soil. This study forms a basis for the development of forest cover with a diverse variety of plants of high economic value on barren patches of land at Gorewada forest by using the biotechnological approach of bioaugmentation.

Keywords: Gorewada forest, Rhizospheric Soils, *Rhizobium*, *Azotobacter*, VAM, bioaugmentation.

Introduction:

Forests are a source of natural habitat for biodiversity and repository of genetic wealth; provide means for recreation and opportunity for eco-tourism. In addition, forests help in watershed development, regulate water regime, conserve soil, and control floods. They contribute to process of carbon sequestration and act as carbon sink, which is important for reduction of green house gases and global warming.

Many parts of country are facing problem of forest resources depletion, due to lack of proper physico-chemical and microbiological status of forest soils. This problem can be alleviated by site-specific soil augmentation process which has now been accepted as a tool for the sustainable management of forest resources. This needs conservation of the stock of natural resources so that sustainable management of forests can be achieved through biological diversity conservation and forest genetic resources, maintenance of ecosystem integrity and site productivity, maintaining the capacity of a forest to regenerate naturally and minimization of adverse environmental and physico-biochemical impacts of forest soils on standing forest. The main aims of the proposed study is to study native plant species of Gorewada forest and to characterize rhizospheric soil of native plant species with respect to its physico-chemical and microbiological properties. This study will help to generate the basic data required for developing an appropriate bioaugmentation process that can be used to resolve the low nutrient status and less counts of useful micro flora present in forest soil.

Materials and Methods:

The Gorewada forest is located in Nagpur at 21^0 45'N latitude and 78^0 15'E longitude. Site surveys were conducted at Gorewada forest during December-2007 to March-2008 During every visit, as many specimens as possible were collected to identify all plants by using reference floras by Hooker (1872-1897), Joshi (2002) and Singh et al., 2001. Besides this, representative soil samples from minimum five rhizosphere of same plant species were collected from each compartment with hand auger, and were mixed in equal proportions to get a composite sample on dry weight basis, air dried, homogenized, sieved through 2.0 mm mesh and stored in polythene bags. Analysis of composite barren, pit and rhizospheric soil samples of dominant plant species available in experimental site were conducted for different physico – chemical and microbiological properties to know the fertility status of the soil. Particle size analysis of soil samples was done by international pipette method (Piper, 1966), Bulk density was determined by clod method (Black et al.; 1965a), Particle density was determined by a pycnometer method (Black et al.; 1965a), Water holding capacity was determined by using Keen- Roozkowski brass boxes (Piper 1965a). The pH and electrical conductivity of soil were determined by using 1:2.5 soil and water suspension ratio (Jackson; 1967), organic carbon was estimated by following Walkly and Black wet digestion method (Black; 1965b). Available N was determined by using alkaline permanganate (Subbaih and Asija; 1956). Available P_2O_5

was determined colorimetrically by following Bray's II method (Black; 1965b). Available K_2O was determined by method of Jackson; 1967. For Total N estimation soil samples were digested using conc. H_2SO_4 (wet digestion) and were subjected to nitrogen distillation by micro Kjeldahl method using Kjel Plus instrument (Tondon; 1993). Total phosphate was estimated by ammonium vanadomolybdate method of Jackson (1967). Total potassium was estimated by using flame photometer (Hesse; 1971). Microbes such as bacteria, fungi, actinomycetes and nitrogen fixing strains of *Rhizobium* and *Azotobacter* were analyzed by following standard procedure for soil microbial populations and were expressed in terms of colony forming units i.e. cfu/g (Black et al.; 1965). Specific growth media for different microorganism were used like Nutrient agar (for total viable count), Rose Bengal Chloramphenicol agar (for fungi), Kenknight and Munaiers medium (for *Actinomycetes*), congo-red yeast extract mannitol agar (for *Rhizobium*), and Jensen's agar (for *Azotobacter*). Vesicular Arbuscular Mycorrhizal (VAM) spores were enumerated by Wet Sieving and decanting technique (Gerdmann and Nicolson; 1963).

Results and Discussion:

Types of Flora present in Gorewada Forest: Study has shown that different types of flora present in Gorewada forest belonged to timber woods species (*Tectona grandis, Gmelina arborea, Azadirachta indica, Ailanthus excelsa*), fuels (wood of *Acacia* sps., *Eucalyptus*), waxes, resins (Pinus sps), aromatics (*Ocimum sanctum, Mentha arvensis, Santalum album, Eucalyptus globulus*, guggal, *Boswellia serrata*), dyes (*Butea monosperma* flowers, *Lawsonia inermis* leaves, *Acacia catechu* (katha) and gums (Gum arabic from *Acacia arabica*). There are more than 182 different plant species classified as trees, shrubs, herbs, climbers and grasses in Gorewada forest. Among the tree species dominant type were *Acacia catechu, A. leucophloea. A. nilotica, Albizia odoratissima, Butea monosperma, Cassia siamea, Mitragyna perbifolia, and Ziziphus mauritiana.* Forest was also characterized to have barren patches which need special treatment for establishment of luxuriant forest cover.

Physico-chemical and microbiological characteristics of rhizospheric soil of dominant plant species of Gorewada forest: Studies on physico-chemical and microbiological characterization of rhizospheric soils of dominant plant species were carried out to understand the physical and nutrient status as well as the levels of useful microflora in the rhizosphere of the plant species. These parameters are the important to determine the fertility of soil. It has been found that physico-chemical characteristics of forest soils vary in space and time because variation in topography, climate, weathering processes, vegetation cover, microbial activities (Paudel and Saha, 2003) and several other biotic and abiotic factors. The yearly contribution of surface vegetation to soil, in the form of needles, leaves, cones, pollen, branches and twigs, gradually decomposes and becomes a part of the soil (Singh and Bhatnagar, 1997). Plant tissues (above and below ground litter) are the main source of soil organic matter, which influences the physico-chemical characteristics of soil such as, texture, water holding capacity, pH and nutrients availability (Johnston, 1986).

Textural classification: Determination of the texture (proportion of sand, silt and clay) of forest soil is also important as it plays a major impact on forest soil productivity. Results of the textural classification i.e. sand, silt and clay percentages of soils of Gorewada forest show that the soil samples analyzed were clayey in texture. The rhizospheric soil of the *Albizia odoratissima* had highest clay content of 62.12 percent and very low content of sand (17.57%) and silts (20.31%). Due to clayey textural class the clay content was high in all the rhizospheric soils of different species as compared to the sand and silt percentages. As basalt (rock) being the parent material for formation of these soils, it is known to impart higher amount of clay to the soil.

Physical properties: The physical properties of soils which comprise of bulk density, porosity and water holding capacity are dominant factors affecting the fertility of forest soil which determine the availability of O_2 in the rhizospheric area of the plant species for efficient nutrient turn over by microorganisms. Results of different physical properties of the soils of Gorewada forest has shown that the barren soil was clayey in texture with low porosity and WHC (51.32% and 50.45%, respectively) and high bulk density (1.29 Mg m^{-3}). The rhizospheric soil showed increase in porosity and WHC percentages due to the presence of vegetation in the soil. This phenomenon was observed in rhizospheric soil of *Albizia odoratissima* which reported the highest WHC (61.45%) and porosity (65.34%)

with the lower BD of 1.10 Mg m^{-3}. Similar findings were observed in the rhizospheric soils of other plant species viz. *Acacia nilotica*, *Mitragyna perbifolia*, *Acacia catechu*, *Ziziphus mauritiana* and *Bauhinia racemosa* where the WHC ranged from 52.65 percent to 61.45 percent. This is probably be due to dense canopy of forest which produced the higher amount of litter that influenced the texture of soil to have higher water retention capacity.

Chemical properties: Forest soil quality with respect to nutrient status can be ascertained by studying soil chemical properties. Results have shown that pH and the EC of this site ranged from 7.12-7.76 and 0.22-0.32 d S m^{-1}, respectively. Soil organic matter (SOM) or soil organic carbon (SOC) is commonly recognized as one of the key chemical parameters of soil quality varied from 1.78 percent in barren soil to the 2.34 percent in the *Mitragyna perbifolia*. The leguminous plant species like *Acacia catechu, Acacia nilotica, Mitragyna perbifolia* and *Tamarindus indica* were reported high organic carbon, viz. 2.90, 2.22, 2.34 and 2.24 percent respectively. The average soil organic carbon was higher in oak forest (2.19 %) followed by pine (1.63 %). Organic matter makes a substantial contribution to the cation exchange capacity (CEC) of the whole soil, and hence to the retention of exchangeable cations. This is because humification produces organic colloids of high specific surface area. The CEC was obviously high in the rhizospheric soil of all the species as compared to the barren soil owing to the fact that the rhizospheric soil exhibits biological nitrogen fixation in leguminous plants; hence rhizosphere contains the higher level of nutrient availability and exchange of the cations and thus CEC is high in the rhizosphere. This observation was found to exist in the rhizospheric soil of the *Mitragyna perbifolia* (60.61CEC cmol (p^+) kg^{-1}) which was followed by that in case of *Tamarindus indica* (58.67 cmol (p^+) kg^{-1}) and 58.20 cmol (p^+) kg^{-1} in the *Acacia catechu*.

Nutrient status: The status and release of nutrients in forest soil are highly linked with microenvironment, litter dynamics, altitude and type of vegetation (Mishra 2011). The total nutrient status of soil studies have shown that the highest N (0.26 %), K (0.57%) and S (0.067%) contents were in the rhizospheric soil of *Acacia catechu,* because the *Acacia catechu* is the leguminous plant which harbors *Rhizobium* in its root nodules and its growth is preferentially stimulated in the rhizosphere of legume than in that of non legumes. Moreover, legumes excrete a large number of substances into the rhizosphere principally sugars, amino acids and vitamins such as biotin and pantothenic acid. Therefore, the total N was high in the rhizosphere of this plant. The K and S content are high due to the rhizospheric effect of soil microorganisms residing in the root zone of *Acacia catechu*. In rhizospheric soils of other plant species the total N ranged from 0.1 to 0.25, P: 0.045 to 0.068; K: 0.27 to 0.45 and S: 0.043 to 0.063 percent. In all the rhizospheric soil of the different plant species, the highest N content was observed in the *Ziziphus mauritiana* (0.022%) followed by the *Mitragyna perbifolia* (0.021%). The P_2O_5 and K_2O contents were high in the *Albizia odoratissima* 0.00129 and 0.00443 percent, respectively. The *Acacia catechu* also showed the high P_2O_5 and K_2O viz. 0.00129 and 0.0435 percent respectively.

Microbiological status: Microorganisms are beneficial in increasing the soil fertility and plant growth as they are involved in several biochemical transformation and mineralization activities in soils. Results of microbiological analysis of rhizospheric soil samples collected from the different plant species available in Gorewada forest have shown that the highest bacterial and fungal count was reported in the rhizospheric soil of *Acacia catechu* (53 x 10^5, 42 x 10^3 c.f.u. g^{-1}, respectively) due to high organic carbon and CEC of the soil. The actinomycetes were highest in the *Bauhinia racemosa* (41 x 10^3 c.f.u. g^{-1}) closely followed by 40 x 10^3 c.f.u. g^{-1} in rhizosphere of *Ziziphus Mauritiana*. The nitrogen fixing bacteria i.e. *Rhizobium* was high in the *Acacia nilotica* (48 x 10^3 c.f.u. g^{-1}) closely followed by the *Acacia catechu* (46 x 10^3 c.f.u. g^{-1}) being a leguminous plant. However, the non symbiotic nitrogen fixing bacteria i.e. *Azotobacter* was highest in the *Ziziphus Mauritiana*. The count of VAM spores was high in the rhizosphere of *Bauhinia racemosa* (12 c.f.u. 10^{-1} g). In the barren soil, the microbiological counts of useful microorganisms was very low owing to low total and available nutrient status of barren soil in terms of contents of carbon, N, P and K levels. Microbes, which were potential as bio-fertilizers were often found in rhizosphere. The following microbes were identified from from rhizospheric soil were namely, *Azospirillum, Rhizpbium Azotobacter, Pseudomonas, Aspergillus* and *Streptomyces* which have potential to become bio-fertilizers or bio-controls. Present study has shown that

the types of microbial communities in the rhizosphere varied largely with the type of plant species due to root zone effect present in the rhizosphere.

Conclusion:

Many parts of country are facing problem of forest resources depletion, due to lack of proper physico-chemical and microbiological status of forests soils which therefore requires sustainable management of forest soil. This can be achieved by understanding the native plant species in and around Gorewada forest, characteristics of rhizospheric soil of native plant species with respect to its physico-chemical and microbiological properties. Results of this particular study formed a basis for developing future plans required for development of forest cover with a diverse variety of plants of high economic value like timber, medicinal and ornamental including even the exotic and rare species by using the biotechnological approach of bioaugmentation.

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