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RESEARCH ARTICLE

IMPACT OF AFFORESTATION ON SOIL HEALTH DIVERSITY IN MAYURESHWAR WILDLIFE SANCTUARY, TAL. BARAMATI, DIST.-PUNE. MAHARASHTRA, INDIA

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ABSTRACT

The forest Department has developed Mayureshwar Wildlife Sanctuary situated near village Supe in Baramati Taluka of Pune Distirct, which is protected for Chinkara (*Gazella gazella bennetti*). For many years the area was barren and remained devoid of any vegetation. The soils lack in humus, contain toxic elements and the status of nutrients is low. Natural colonization and its development into an ecosystem are slow and stochastic processes. Systematic plantations were undertaken on a large scale in the year 1982-83. The species like *Acacia nilotica* Delile ssp. *indica* Brenan, *Acacia torta* (Roxb.) Criab.(syn. *A. spirocarpa* Hochst. ex A.Rich.) (*A. tortilis* Hayne.), *Azadirachta indica* A. Juss, *Balanites aegyptiaca* (L) Del.: *Dalbergia sissoo* Roxb., *Eucalyptus globulus* Labill.(hybrid), *Gliricidia sepium* (Jacq.) Kunth. ex Walp, *Leucaena latisiliqua* (L.) Gills, *Prosopis cineraria* (L.) Druce, *Prosopis julifera* (Sw.) DC, *Stylosanthes humata* Taub. were planted in some patches and these species too have faired very well. As a part of habitat improvement grass species like Shedya (*Sehima nervosum* Stapf.), Pavnya (*Ischaemum semisagittatum* Stapf..ex Fisch.), Marval (*Dichanthium annulatum* (Forssk.) Stapf). were sown. Due to vegetation cover and enrichment of bio-mass made changes in physical properties of soil, microbial and mycological diversity in soil samples of protected area of MWLS.

INTRODUCTION

The soil cover and ecological systems of the earth differ according to continents, natural zones and regions. Territories of similar climate, topography, geology and natural evolution have similar soils. Soil cover has formed during thousands of years of evolution and in the conditions fully non-existent now. This considerably steps up the importance of proper and effective utilization and preservation of soil resources not only as an object of agriculture but as an important link in the global mechanism of the biosphere. Global soil cover is a most valuable natural source of wealth of any nation. The deforestation has caused total denudation of previously flourishing landscapes. In the past, erosion destroyed not less than 450-500 million hectares of land. At national and international level efforts should be aimed at the soil studies, evaluation and effective utilization of soil resources (Kovda, 1978). In this regard, several studies related to vegetation and soil are conducted in different parts of world. The effects of trees on soil physical properties also differ with the age of plantation. The surface soils of young teak plantations exhibited higher values for apparent density and absolute specific gravity and relatively lower values for pore space, water holding capacity and percentage volume expansion. It was established that the physical conditions of soils are positively influenced only a period of 30 years after plantation. It was also observed that effects of afforestation on soil properties like pore volume and bulk density as function of age of plantations (Jose and Koshy, 1972). Ohta (1990) supported the fact that these influence also differed with kinds of plantation species and it has been observed that the hydraulic conductivity increased in the *Acacia auriculiformis*, a tropical plantation species and decreased in *Pinus kesiya*, a conifer species. A four year old *Acacia auriculiformis* plantation increased the soil pH from 5.9 to 7.6 and enhanced the soil electrical conductivity (Chakraborty and Chakraborty, 1989). When compared with the other species, pH under *Acacia auriculiformis* is lower and it is reported that top soil pH increases with increasing Ca levels in litter. The soil reaction of the planted *Prosopis* area shifted slightly towards acidic range but the change was within the normal limits (Srivastav, 1993). As the depth of soil increased, the pH changed from acidic to neutral in deep layers in *Eucalyptus* hybrid plantations (Kushalappa, 1985) and similar results were reported in *Casuarina* plantation (Jambulingam, 1989). The organic carbon content was high in the surface soils and decreased with the depth in the Eucalyptus plantations of Kerala (Balagopalan *et al*., 1992). The role of free living soil

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organisms in the regeneration of tropical fallows has also been deduced form the presence of microflora population in plantation soils as comparable to fallow lands (Nye and Greenland, 1962). Soils of *Eucalyptus calophylla* and *Eucalyptus marginata* contained larger microflora population than in bare soils. Eucalyptus seedlings raised in loam soil harbored greater microbial populations than those in lateritic soils (Malajczuk and Cromack, 1982). Microbial groups (bacteria, actinomycetes and fungi) in deserts and semi arid woodlands were only 10-30 percent as abundant as in forest habitat (Bamforth, 1984). Mayureshwar Wildlife sanctuary has been studied on different aspects like floristic point of view and habitat conservation in relation to ecological aspect of Chinkara wild life. (Ben *et al*, 2006. 2007, 2011, 2013). Present investigation of soil composition, micro-flora and myco-flora from protected area like MWLS has not reported earlier. The systematic work carried out is presented in this paper.

MATERIALS AND METHODS

The present study carried out at Mayureshwer Wild life Sanctuary situated at 18^0 20' 11 N and 74^0 22' 23 E. falls in the biogeographic province 6B in village Supa of Baramati Taluka of Pune district. The entire tract of village Supa and adjoining villages come under the drought prone area and receives scanty rainfall during the rainy season. Ecological studies were carried out since 2003- 2005. One of the aspect of soil analysis, soil microbes and soil fungi were analysed systematically. Soil samples were taken carefully from six different sites in four season of habitats depending on the area. These soil samples were sent for analysis to the Soil Conservation Department Maharashtra State, Pune. The collected soil samples were analysed for various physical, chemical and physico chemical properties viz. Soil reaction (pH), Electrical conductivity, organic matter, Nitrogen, Phosphorus and Potash. The samples from all the six locations were analyzed for various physical and chemical properties as per standard procedures mentioned by Piper (1996), Walkely and Black (1934), Subbiah and Asija (1956), Bray and Kurtz (1945), Rovira and Vallejo (1997) for other modern methods for microflora and chemical composition.

Method for microbiological analysis

The soil sample collected were homogenized by sieving (2 mm mesh) and stored at 4^oC. Some samples were also collected from the root zones of *Acacia torta* (Roxb.) Craib. *Gliricidia* sepium (Jacq.) Kunth. ex Walp. and *Dalbergia sissoo* Roxb. The maximum microbial growth and activity in the soil is found around the roots of plants. This region is called the rhizosphere. Practically all ecological interactions, such as symbiosis, syntrophism, synergism, commensalism and antagonisms between plants and micro-organisms among different microorganisms are found in this region. The most important function of soil microorganisms is to decompose various kinds of organic matter. (Powar and Diginwala, 1994). The microbes were isolated on sterile media namely Potato Dextrose Agar (fungi), Luria Agar (Bacteria) and Casein starch Agar (Actinomycetes) using streak plate and spread plate methods. All the isolates were purified and their respective activities of significance in the soil viz. cellololytic, Amylolytic, Phosphate solubilizing, Sulphate reduction, Nitrogen fixing and Denitrifying were respectively studied on sterile media namely, CMC agar, Starch agar, Pikowasky's agar, 2% peptone water broth, Ashby's agar and Nitrate reduction medium. The microbial diversity with reference to these enzyme activities were determined (Pelczar & Reid, 1958). Microbial culture preparation and their identification were carried out at Microbiology Department, Modern College, Pune.

Method for Mycological analysis

About 10 g of soil sample were collected from across the MWLS in different paper bags and mixed thoroughly. The mixed samples were ground fine. The fungal strains were isolated by the Serial Dilution technique. 10 g of soil sample was weighed and taken in a measuring cylinder and made up to 100 ml with distilled water. One ml of suspension was transferred to 9 ml of sterile water (1:100) after shaking well. Serial dilution was made by transferring 1 ml of the suspension to subsequent tubes to get 1:10000. Then 1 ml of the dilution was transferred to the Petri plate. 20 ml of melted and cooled selective medium was poured in the Petri plate already containing 1 ml of soil suspension. The suspension and the melted medium were mixed well by gently rotating. The plates were incubated at 25ºC for 5 days time. The individual colonies were transferred to the fresh plates and maintained on agar slants. Potato Dextrose Agar medium was used for isolation and cultivation of fungi from soil samples. The sporulation structures produced by the fungi were considered as diagnostic characters for their identification. The identity of fungi was confirmed with the help of monographs, reviews and standard books (Subramanian, 1971; Ellis, 1971, 1976; Von Arx, 1974; Sutton, 1980; Sarbhoy *et al*. 1980, 1996; Domsch *et al*., 1980; Pande, 2008). Fungi from soil samples were identified at Ajerekar Mycological Herbarium at Agharkar Research Institute, Pune.

RESULTS

The soil samples in all the six quadrats were statistically analysed for the presence of Soil pH (Table 1), Electrical conductivity (Table 2), Potassium (Table 3) and Phosphorus (Table 4) and Nitrogen (Table 5).

Table 1. Effect of vegetation on soil properties - soil pH

Plot	S1	S2	S3	S4
P1	7.47	7.48	7.46	7.45
P2	7.12	7.11	7.10	7.13
P3	7.11	7.09	7.12	7.10
P4	7.13	7.10	7.11	7.12
P5	7.12	7.14	7.13	7.11
P6	7.15	7.16	7.14	7.12
Season Mean	7.183	7.18	7.176	7.171
	P	S	P X S	
S.E.D.	0.0156	0.128	0.0312	
C.D.(P=0.05)	0.03152	0.256	0.624	

Table 2. Effect of Vegetation on Soil Properties – Soil Electrical conductivity (dSm-1)

Plot	S1	S2	S3	S4
P1	0.44	0.41	0.4	0.42
P2	0.29	0.27	0.25	0.24
P3	0.2	0.19	0.17	0.16
P4	0.24	0.21	0.2	0.19
P5	0.32	0.3	0.31	0.32
P6	0.25	0.23	0.22	0.21
Season Mean	0.29	0.268	0.258	0.256
	P	S	P X S	
S.E.D.	0.0025	0.002	0.0049	
C.D.(P=0.05)	0.005	0.004	0.0098	

Table 3. Effect of Vegetation on Soil Properties – Soil Potassium (kg/ha)

Plot	S1	S2	S3	S4
P1	376.32	375.12	375.87	376.43
P2	430.08	431.12	432.43	430.01
P3	349.44	350.41	349.12	348.13
P4	362.88	363.12	362.12	360.39
P5	403.2	401.12	407.18	410.34
P6	349.44	353.12	361.23	363.53
Season Mean	378.56	379.00	381.32	381.47
	P	S	P X S	
S.E.D.	3.35	1.92	4.71	
C.D.(P=0.05)	4.76	3.89	9.53	

Table 4. Effect of Vegetation on Soil Properties – Soil Phosphorus (kg/ha)

Plot	S1	S2	S3	S4
P1	20.59	20.19	21.17	20.49
P2	15.58	15.41	15.31	14.13
P3	22.26	22.17	21.93	22.47
P4	17.81	16.71	16.10	17.14
P5	15.58	15.10	14.93	15.12
P6	19.48	17.40	17.11	19.64
Season Mean	18.55	17.83	17.76	18.16
	P	S	P X S	
S.E.D.	0.06	0.04	0.12	
C.D.(P=0.05)	0.12	0.09	0.24	

Table 5. Effect of Vegetation on Soil Properties – Soil Nitrogen (kg/ha)

Plot	S1	S2	S3	S4
P1	0.224	0.214	0.21	0.209
P2	0.326	0.316	0.312	0.315
P3	0.204	0.201	0.202	0.205
P4	0.285	0.261	0.271	0.275
P5	0.367	0.36	0.365	0.37
P6	0.265	0.259	0.252	0.259
Season Mean	0.2785	0.2685	0.2686	0.2721
	P	S	P X S	
S.E.D.	0.0016	0.0013	0.0032	
C.D.(P=0.05)	0.0032	0.0026	0.0064	

Soil Fungi

The MWLS soil sample exhibited 32 species

Fungi encountered from soil samples

1. *Aspergillus flavus gr.*
2. *Aspergillus niger gr.*
3. *Aspergillus oryzae* (Ahlburg) Cohn
4. *Alternaria alternate* (Fr.) Keissler
5. *Aspergillus terreus gr.*
6. *Aureobasidium* sp.
7. *Chrysosporium* sp.
8. *Cladosporium oxysporum* Berk & Curt.
9. *Colletotrichum gloeosporioides (*Penz.) Sacc.
10. *Cuvularia lunata* (Wakker) Boedijn
11. *Fusarium moniliforme* J. Sheld
12. *Fusarium oxysporum* Schlecht.
13. *Fusarium solani* (Mart.) Sacc.
14. *Geotrichum candidum* Link: Pers.
15. *Gliocladium* sp.
16. *Melanospora* sp.
17. *Mucor hiemalis* Wehmer
18. *Penicilium aurantiogriseum* Dierckx
19. *Penicillium citrinum* Thom
20. *Penicillium* sp.
21. *Petalotiopsis* sp.
22. *Phoma* sp.
23. *Rhizoctonia solani* Kuhn
24. *Rhizopus oryzae* Went & Prinsen Geerligs
25. *R. stolonifer* (Ehrenb.: Link) Lind
26. *Scytalidium* sp.
27. *Sordaria* sp.
28. *Syncephalastrum racemusum* Cohn : Schrot.
29. *Trichoderma harzianum* Rifai
30. *Trichoderma koningii* Oudem
31. *Trichoderma viride* Per.: S. F. Gray
32. *Trichothecium roseum* (Pers.) Link : Gray

DISCUSSION

In general forest vegetation profiles with more organic matter will have lower bulk density and higher hydraulic conductivity (Mathan and Kannan, 1993) (Lal, 1987) (Yadav, 1980). Srivastav and Ambasht (1995) reported that the distribution of nutrients in the profile varies. About 2/3rd of the carbon and Nitrogen stores were usually contained in surface soils (Ah horizons) and 1/3rd in OH layer. About 20 percent of total P were reported to be met from OH and Ah layers. In the forest soils having mixed tree species, the total P and K content were 0.9 percent and 0.3 percent respectively as reported by Negi *et al*. (1988). Agarwal *et al*. (1993) found that the soils of *Prosopis cineraria* had higher content of total N and P and available N, P and K than adjacent open lands. Kushalappa (1985) reported that the available P and available K content decreased with increasing depth in the Eucalyptus hybrid plantation in Bangalore. In the soil profiles of Chakrata forest division the content of N was high in the upper layer and decreased in the lower horizons. Similarly the P content was low and followed the above trend. The K content also ranged from 0.21- 2.95 percent. The available P and K content were reported to range from 0.002 -0.004 percent and 0.017 -0.048 percent respectively (Yadav and Sharma, 1968).

The MWLS has plantations of *Acacia torta* (Roxb) Criab, *Azadirachta indica* A. Juss., *Leucaena latisiliqua* (L.) Gills, *Albizia procerea* (Roxb.) Benth, *Prosopis juliflora* (Sw.) DC., and *P. cineraria* (L.) Druce *Eucalyptus globule Labills*, *Dalbergia sisoo* Roxb. and *Erythrina indica* Lam. As a part of habitat improvement works the grass species like Shedya (*Sehima nervosum* Stapf.), Pavnya (*Ischaemum semisagittatum* Stapf. ex Fisch.), Marval (*Dichanthium annulatum* (Forssk.) Stapf), Hamata (*Stylosanthes humata* Taub.) etc. were sown. Plantation of trees and broadcasting of grasses and legume seeds has changed the structure of soil; accumulated nutrients both in plant and soil. The capacity to fix atmospheric nitrogen allows legumes to establish and grow in nitrogen- deficient soils. *Prosopis cineraria* (L.) Druce, *Leucaena latisiliqua* (L.) Gills. and *Gliricidia sepium* (Jacq.) Kunth. ex Walp. are reported to fix very high amount of nitrogen. Thorny shrubs and trees species of *Acacia* are suitable for reclamation and afforestation of various wastelands. They control wind, water and rain-erosion, some species are salt-resistant and fixing nitrogen. These species are planted for fodder and feed of wild animals. They thrive in the most severe environmental conditions and can be planted on sodic and alkaline soils. Once established, they can create conditions suitable for other species. The soil of the MWLS represented neutral status all

through the four seasons. The soil being scanty and deficient in soil nutrients has not supported vegetation for longer duration. The *Azadirachta indica* plantations exhibited a slightly acidic pH. Similar results were reported in sandy loamy top soil sporting *Azadirachta indica* plantations (Drechsel and Schmall, 1990). The area having the *Prosopis cineraria* cover also exhibited neutral status in all the seasons. Studies conducted under *Prosopis cineraria* plantations revealed that the soil reaction of the planted area shifted towards acidic range but the change was within the normal limits (Srivastav, 1993). The other quadrats also revealed soil reaction closer to neutral status in all the four seasons. The Electrical conductivity of the soils of MWLS showed a range of 0.16 to O.44dsm-1. Soils of *Acacia torta* plantations showed Electrical conductivity of 0.30 DSm-1. A four year old *Acacia auriculiformis* plantation enhanced the Soil Electrical conductivity. In the barren area of MWLS, the electrical conductivity exhibited an average of 0.32dsm-1. The study conducted in the 25 to 30 years old teak plantation of Seoni and Raipur forest in Madhya Pradesh (Totey *et al*., 1992) showed lower Electrical conductivity compared to the barren soil. The MWLS soils reported K content of 381 kg / ha and P content of 18 kg/ ha, which is lower as far as forest soils are concerned.

The amount of total and available K was moderate to low in the forest soils. The quadrat supporting *Prosopis cineraria* plantations showed K content of 349 kg/ha. The K content was 0.3 percent in the forest soils having mixed tree species. The decomposition of litter that accumulates beneath *Prosopis* plants results in a marked increase in soil N. In contrast, very little N accumulates at depth near the water source since this zone is continually moist and any N which is released from root and nodule turnover is taken up by roots. Consequently, a mechanism is in place to keep soil N from accumulating at depth in concentrations that would inhibit N_2-fixation In contrast, low water availability near the soil surface limits root activity to short periods and prevents complete uptake of mineralized and nitrified N (Virginia, 1986). The soils of MWLS reported N content 0.27 kg/ha which is lower compared to a normal forest stand. Verma and Sharma (1978) reported that the forest soils of Bhata region were found to be medium in available N content. Successful mobilization of nutrients is possible through rapid breakdown of key nutrient elements favored by the enzymes. Very few studies have been carried out in assessing the microbial diversity of protected areas in India.

Presence of enzymes in soil and pellets of wild animals in varying amounts as influenced by species and habitat is critical in nutrient translocation. In the present soils a small or large quantities of enzymes are indirect evidence on the successful colonization of species. MWLS showed microbial populations in the Rhizosphere soils. In the present investigation, large number of isolates showed cellolytic and amylolytic activities indicating their participation in the carbon cycle of the region. Similarly good number of isolates with Nitrogen and denitrifying abilities indicate their role in the Nitrogen cycle. The translation of soil nutrient reserves into plant available nutrient is related to soil enzyme activity. (Kramer and Yerdie, 1958). The level of enzyme activity mirrors the level of soil fertility. (Skujins, 1978). The study also revealed absence of Sulphate reducing and Phosphate solubilizing activity. These isolates can be applied as Bio-fertilizers and their beneficial role to the plants. Microorganisms active in the soil are largely responsible for the biogeochemical cycles that support life on Earth (Paul and Clark, 1996). Soil is a very complex system that comprises a variety of microhabitats with different physicochemical gradients and discontinuous environmental conditions. Microorganisms adapt to microhabitats and live together in consortia with more or less sharp boundaries, interacting with each other and with other parts of the soil biota. A number of investigations emphasize the impact of soil structure and spatial isolation on microbial diversity and community structure (Tiedje, *et al* 2001, Sessitsch 2001).

Analysis of the spatial distribution of bacteria at microhabitat levels showed that, in soils subjected to different fertilization treatments, more than 80% of the bacteria were located in micro-pores of stable soil micro-aggregates (2–20 µm). Such microhabitats offer the most favorable conditions for microbial growth with respect to water and substrate availability, gas diffusion and protection against predation. Particle size has a higher impact on microbial diversity and community structure than factors like bulk pH and the type and amount of organic compound input. Results showed that the microbial diversity in fractions with small soil particles was higher than that in fractions with large soil particles. Most of the soil microbial community was particle-specific. Soil harbors four major groups of micro-flora viz. bacteria, fungi, actinomycetes and algae. Most types of bacteria and all fungi are heterotrophs (Pritchett and Fischer, 1987). The top soil is the region of enhanced microbial proliferation resulting from the plant root influence (Giddens and Todd, 1984). It is the zone where micro-flora are stimulated prior to pathogenesis (Rovira, 1979). Microorganisms rapidly colonize the growing roots within the first cm from the tip and these collectively exhibit strong antagonism to root pathogens which may be looked upon as a biological mechanism (Baker, 1968). Correlation between occurrence of non pathogenic microorganisms in the rhizosphere and resistance of root tissue to infection by root pathogens in their process of establishment is well known (Strzelezyk, 1985).

The mycological observations in the soils of MWLS. There were 32 fungi forms, *Aspergillus flavus gr., Aspergillus oryzae* (Ahlburg) Cohn, *Cladosporium oxysporum* Berk & Curt., *Colletotrichum gloeosporioides (*Penz.) Sacc., *Fusarium solani* (Mart.) Sacc*, Geotrichum candidum* Link: Pers*., Mucor hiemalis* Wehmer, *Penicilium aurantiogriseum* Dierckx, *Penicillium citrinum* Thom, *Rhizoctonia solani* Kuhn, *Syncephalastrum racemusum* Cohn: Schrot, *Trichoderma harzianum* Rifai, *Trichoderma koningii* Oudem, *Trichothecium roseum* (Pers.) Link : Gray, etc. They played an important role in the ecosystem, responsible for recycling of nutrients. During the field collection some mushrooms are also encountered such as *Ganoderma applanatum* (Pax) Pat, *Macrolepiota procera* Singh and *Phallus impudiues* L. Ex Pers. A comparison of fungi in forest and cultivated soil indicated that Penicillium spp. and various mucorales were common in forests with Fusarium and Aspergillus dominant in cultivated fields (Miller *et al*., 1957). Nipunage, *et al.* (2009) carried out ecological survey of sacred groves (forest preserved on religious grounds) from Malshej ghat, Pune district and recorded floristic diversity, soil analysis and myco-flora from five sacred groves. During the mycological survey

in sacred groves hyphomycetes were reported. This indicates that forest cover has great potential in recent years in fungal diversity. The tree species will improve the soil physical properties through elimination of surface soil disturbance. Presence of leaf litter encourages activity of soil microbes, fungi, fauna and through augmentative effects of root channels on total and macro-porosity. There is an appreciable influence of afforestation on habitat and effect of soil properties differs with the kind of vegetation cover. (Nishijima and Nakata, 2004)

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