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PHYSICO-CHEMICAL CHARACTERIZATION OF FOREST SOILS OF DANG'S DISTRICT, GUJARAT, INDIA

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ABSTRACT

The present study was conducted on physico-chemical characterization of different soil depths of five forest ranges at Dang's district of Gujarat which is well known as shares few extensions of Western Ghats. The analysis indicates that soil at all location were acidic and there was an increasing trend of soil pH with an increase in depth of soil. The soil pH ranged from 6.10±0.10 to 6.40±0.35, 6.16±0.47 to 6.55±0.44 and 6.34±0.47 to 6.67±0.10 with respect to soil depths 0-30, 30-60 and 60-90 cm, respectively. Similar trend was found in other parameters like particle density, bulk density, electric conductivity, organic carbon, available nitrogen, phosphate and potash, but reserves trend found in water holding capacity and porosity. The organic carbon value ranged 0.77±0.04 to 0.86±0.01, 1.37±0.04 to 1.42±0.01 and 1.76±0.02 to 1.83±0.03 tCha^{-1}; nitrogen ranged 275.14±37.98 to 334.92±31.08, 113.89±12.47 to 218.59±22.46 and 103.55±25.20 to 174.99±39.14 Kgha^{-1}; phosphorus ranged 32.67±4.94 to 53.44 ±10.40, 24.95±3.54 to 42.95±4.27 and 20.60±3.45 to 37.07±6.29 Kgha^{-1} and potash ranged 349.30±45.98 to 421. 66±47.53, 281.69±37.71 to 342.87±36.97 and 214.76±24.53 to 239.56±22.42 Kgha^{-1} at soil depths 0-30 cm, 30-60 cm and 60-90cm, respectively. Understanding species-specific differences in tree-soil interactions have immediate interest to foresters concerned with maintaining or increasing site productivity.

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INTRODUCTION

The growth and reproduction of forest cannot be understood without the knowledge of soil. The soil and vegetation have a complex interrelation because they develop together over a long period of time. The vegetation influences the chemical properties of soil to a great extent (Gairola *et al.,* 2012; Karlikar and Solanki, 2014). The concept of soil quality includes assessment of soil properties and processes as they related to ability of soil to function effectively as a component of a healthy ecosystem. Specific functions and subsequent values provided by forest ecosystems are variable and rely on numerous soil physical, chemical, biological properties and processes, which can differ across spatial and temporal scales. Soil characteristics and biodiversity of the ecosystem are influenced by various factors such as land use, climate change etc. Maintenance of the soil characteristics and subsequently raising the biomass production is a difficult task and it is a common problem for the forester (Karia and Kiran, 2004). Climate, organisms, topographic relief and parent material interacting through time are the dominant factors that control the processes of soil formation and determine soil properties. In general, tree represents both conducts through which nutrients cycle and sites for the accumulation of nutrients within a landscape. From an ecological prospective, the soil patches found beneath tree canopies are important local and regional nutrient reserves that influence community structure and ecosystem function (Rhoades, 1996).

Foresters have always relied on knowledge of chemical and physical properties of soils to assess capacity of sites to support productive forests. Recently, the need for assessing soil properties has expanded because of growing public interest in determining consequences of management practices on the quality of soil relative to sustainability of forest ecosystem functions in addition to plant productivity (Schoenholtz *et al.,* 2000). Forest soils in comparison to other soils are characterized by the presence of litter with an associated unique micro flora and fauna, higher porosity, higher permeability, more stable soil aggregates and greater water holding capacity. Trees may play a major role in increasing soil fertility through the ecological and physicochemical changes they induce in soil (Singh *et al.,* 2002). The improvement of physical properties of soil influence by climatic and season changes (Tansley, 1949), different tree species, biotic and abiotic factors (Norris, 1970), forest cover (Rathod and Devar, 2003), Afforestation (Ceyhun *et al.,* 2010), tourism, festivals and recreational stress (Meric *et al.,* 2010). The flora and fauna of a particular ecosystem indicates the biodiversity of that ecosystem and it is the indicator of overall good health of that ecosystem (Everard, 2004). Meager information is available regarding Dang's forest soil status. There are also some possibilities that over the year's fertility exhaustion could have been occurred due to some high nutrient demanding plants, soil erosion and anthropogenic activities. The knowledge of soils for their nutrient supply capacity helps in deciding the appropriate cultural practices and selection of proper rate of nutrients to supply. Therefore this study was planned to investigate the nutrients availability status and their relationship with soil properties.

MATERIALS AND METHODS

The present investigation was carried out at Dang's district of Gujarat which is well known as shares few extensions of Western Ghats (Kumar *et al.,* 2013, Kumar *et al.,* 2014a, Kumar, 2015) located at longitude 20º-33' to 20º-53' N and latitude 73º-39' to 73º-43' E at an altitude of 110 m above Mean Sea Level during March, 2011 to February, 2012. The area experiences an average annual rainfall of 1831 mm and the lowest temperatures are recorded in December or January (10ºC to 33.7ºC). The soil samples were collected using soil auger at a depth of 0 to 30 cm, 30-60 cm and 60-90 cm, after scrapping away the litter from five forest ranges in Dang's district viz Waghai, Chikhali, Ahwa, Mahal and Saputara for analysis of soil properties. In order to assess the available nutrients in the soil media, the soil samples in three replications were air-dried at room temperature. The soil was fine ground and prepared samples by passing through 2 mm sieve and analyzed for the soil physical properties such as particle density, bulk density, water holding capacity was estimated by Black method (1965) and porosity was measured by the formula $[100 - \frac{\text{Bulk Density}}{\text{Particle Density}} \text{X} 100$ The chemical properties of the soil such as pH measured by Potentiometry method (Jackson, 1973), electrical conductivity was measured by Schofield method (Jackson, 1973), soil organic carbon was measured by Walkley and Black's rapid titration method, available nitrogen was estimated by Kjeldhal's method (Piper, 1960), P as suggested by Olsen's method (Olsen's *et al.,* 1954) and available K by Flame photometer (Jackson, 1973).

RESULTS

The results of physical parameters of the soil from different forest ranges in Dang's district have are given in Table 1 and values of chemical parameters have given in Table 2. An increasing trend in particle density was recorded with an increase in depth of soil and it was in the order 0-30 cm < 30-60 cm < 60-90 cm (Table 1). In all locations, Particle density ranged from 2.54 ± 0.01 to 2.59 ± 0.02, 2.64 ± 0.00 to 2.66 ± 0.00 and 2.75 ± 0.00 to 2.79 ± 0.00 gcm^{-3} at soil depths 0-30 cm, 30-60 cm and 60-90 cm, respectively. Among the different ranges, at depth gradients of 0-30 cm, 30-60 cm and 60-90 cm, higher particle density was found in Saputara (2.59 ± 0.02, 2.66 ± 0.00 and 2.79 ± 0.00 gcm^{-3} respectively) range followed by Waghai (2.57 ± 0.03, 2.66 ± 0.00 and 2.75 ± 0.01 gcm^{-3}, respectively) range and the least was found at Chikhali (2.55 ± 0.01, 2.64 ± 0.00 and 2.75 ± 0.00 gcm^{-3}, respectively) range (Table 1).

Whereas, a decreasing trend in bulk density was recorded with an increase in soil depth and it was in the order 0-30 cm > 30-60 cm > 60-90 cm. Among the different locations, bulk density ranged from 1.09 ± 0.01 to 1.12 ± 0.02, 1.17 ± 0.01 to 1.44 ± 0.01 and 1.51 ± 0.06 to 1.64 ± 0.01 gcm^{-3} at soil depths 0-30 cm, 30-60 cm and 60-90 cm, respectively (Table 1). Of the five different forest ranges, at depth gradients of 0-30 cm, 30-60 cm and 60-90 cm, a relatively greater bulk density was found in Saputara (1.12 ± 0.00, 1.44 ± 0.01 and 1.64 ± 0.01gcm^{-3}, respectively) followed by Chikhali (1.12 ± 0.02, 1.34 ± 0.02 and 1.62 ± 0.01gcm^{-3} respectively) and the least was found in Waghai forest range (1.09 ± 0.01, 1.17 ± 0.01 and 1.59 ± 0.00gcm^{-3}, respectively).

Similar to bulk density, water holding capacity also decreased with increase in depth of soil. For entire locations, water holding capacity ranged from 46.53 ± 1.63 to 59.40 ± 1.12, 45.59 ± 0.06 to 55.69 ± 0.30 and 43.16 ± 0.42 to 51.95 ± 0.03% at depths 0-30 cm, 30-60 cm and 60-90 cm, respectively (Table 1). Among the five forest ranges, at all depth gradients of 0-30 cm, 30-60 cm and 60-90 cm, higher water holding capacity was found in Saputara (59.40 ± 1.12, 55.69 ± 0.30 and 51.95 ± 0.03%, respectively) followed by Ahwa (53.76 ± 2.13, 51.13 ± 0.18 and 47.85 ± 0.17%, respectively) and the least was found in Chikhali (46.53 ± 1.63, 45.59 ± 0.06 and 43.16 ± 0.42%).

The perusal of data revealed that decreasing trend of average porosity with an increase in depth of soil. At different locations porosity ranged from 56.19 ± 0.80 to 57.32 ± 0.25, 45.99 ± 0.28 to 55.87 ± 0.48 and 41.16 ± 0.26 to 45.63 ± 2.27% at depths 0-30 cm, 30-60 cm and 60-90 cm. With regard to locations, the highest porosity was recorded in Waghai (57.32 ± 0.25, 55.87 ± 0.48 and 42.05 ± 0.40% at 0-30 cm, 30-60 cm and 60-90 cm respectively) and was followed by Ahwa (56.68 ± 1.79, 52.90 ± 0.27 and 42.40 ± 0.54%)

Table 1: Physical properties of the soil in different depths of five forest ranges in Dang's district, Gujarat, India

Place	Depth	Particle Density (gcm^{-3})	Bulk Density (gcm^{-3})	Water Holding Capacity (%)	Porosity (%)
Waghai	0-30 cm	2.57 ± 0.03	1.09 ± 0.01	50.80 ± 1.20	57.32 ± 0.25
	30-60 cm	2.66 ± 0.00	1.17 ± 0.01	48.70 ± 0.06	55.87 ± 0.48
	60-90 cm	2.75 ± 0.01	1.59 ± 0.00	47.21 ± 0.02	42.05 ± 0.40
Chikhali	0-30 cm	2.55 ± 0.01	1.12 ± 0.02	46.53 ± 1.63	56.19 ± 0.80
	30-60 cm	2.64 ± 0.00	1.34 ± 0.02	45.59 ± 0.06	49.37 ± 0.93
	60-90 cm	2.75 ± 0.00	1.62 ± 0.01	43.16 ± 0.42	41.16 ± 0.26
Ahwa	0-30 cm	2.56 ± 0.01	1.11 ± 0.04	53.76 ± 2.13	56.68 ± 1.79
	30-60 cm	2.64 ± 0.01	1.24 ± 0.00	51.13 ± 0.18	52.90 ± 0.27
	60-90 cm	2.76 ± 0.00	1.59 ± 0.01	47.85 ± 0.17	42.40 ± 0.54
Mahal	0-30 cm	2.54 ± 0.01	1.09 ± 0.03	54.36 ± 0.93	57.20 ± 1.28
	30-60 cm	2.64 ± 0.01	1.35 ± 0.01	46.56 ± 0.08	48.85 ± 0.50
	60-90 cm	2.78 ± 0.00	1.51 ± 0.06	44.82 ± 0.10	45.63 ± 2.27
Saputara	0-30 cm	2.59 ± 0.02	1.12 ± 0.00	59.40 ± 1.12	56.49 ± 0.40
	30-60 cm	2.66 ± 0.00	1.44 ± 0.01	55.69 ± 0.30	45.99 ± 0.28
	60-90 cm	2.79 ± 0.00	1.64 ± 0.01	51.95 ± 0.03	41.35 ± 0.25

Table 2: Chemical properties of the soil in different depths of five forest ranges in Dang's district, Gujarat, India

Place	Depth	pH	EC (Sm^{-1})	C ($tCha^{-1}$)	Available N($kgha^{-1}$)	Available P_2O_5 ($kgha^{-1}$)	Available K_2O_2 ($kgha^{-1}$)
Waghai	0-30 cm	6.40 ± 0.35	0.32 ± 0.02	0.77 ± 0.04	312.68 ± 14.26	32.67 ± 4.94	397.97 ± 32.28
	30-60 cm	6.53 ± 0.38	0.36 ± 0.01	1.37 ± 0.04	201.13 ± 20.95	24.95 ± 3.54	329.82 ± 22.11
	60-90 cm	6.59 ± 0.35	0.40 ± 0.01	1.79 ± 0.03	149.58 ± 14.03	20.60 ± 3.45	239.56 ± 22.42
Chikhali	0-30 cm	6.30 ± 0.36	0.20 ± 0.02	0.80 ± 0.03	305.45 ± 24.91	53.44 ± 10.40	361.80 ± 40.29
	30-60 cm	6.43 ± 0.37	0.26 ± 0.03	1.39 ± 0.03	184.91 ± 22.94	42.95 ± 4.27	289.66 ± 28.17
	60-90 cm	6.55 ± 0.44	0.31 ± 0.04	1.80 ± 0.02	134.11 ± 22.35	37.07 ± 6.29	219.19 ± 22.80
Ahwa	0-30 cm	6.10 ± 0.52	0.17 ± 0.03	0.85 ± 0.02	275.14 ± 37.98	35.27 ± 7.62	349.30 ± 45.98
	30-60 cm	6.16 ± 0.47	0.20 ± 0.02	1.41 ± 0.02	153.68 ± 20.72	31.84 ± 5.79	281.69 ± 37.71
	60-90 cm	6.34 ± 0.47	0.25 ± 0.02	1.76 ± 0.02	110.75 ± 19.89	26.79 ± 6.32	214.76 ± 24.53
Mahal	0-30 cm	6.23 ± 0.25	0.30 ± 0.02	0.86 ± 0.01	328.67 ± 17.08	40.84 ± 11.29	421.66 ± 47.53
	30-60 cm	6.37 ± 0.31	0.36 ± 0.03	1.39 ± 0.01	113.89 ± 12.47	32.79 ± 5.24	342.87 ± 36.97
	60-90 cm	6.48 ± 0.22	0.41 ± 0.02	1.74 ± 0.02	103.55 ± 25.20	29.42 ± 6.52	228.20 ± 19.67
Saputara	0-30 cm	6.10 ± 0.10	0.27 ± 0.01	0.82 ± 0.03	334.92 ± 31.08	41.02 ± 4.14	414.38 ± 27.07
	30-60 cm	6.34 ± 0.05	0.31 ± 0.01	1.42 ± 0.01	218.59 ± 22.46	36.70 ± 5.48	332.21 ± 17.10
	60-90 cm	6.67 ± 0.10	0.35 ± 0.02	1.83 ± 0.03	174.99 ± 39.14	32.41 ± 5.40	233.02 ± 15.00

(Table 1). The least porosity was observed in Chikhali forest range (56.19 ± 0.80, 49.37 ± 0.93 and 41.16 ± 0.26%).

Analysis of results indicated that the soil at all locations were acidic and it increased with an increase in depth of soil. It may be due to rapid weathering and intense leaching under high rainfall condition factors the development of soil acidity and also the effects exerted by geological and environmental factors added by change in the land use pattern and uncontrollable climate change.(Pati et al., 2014). In all locations, average soil pH ranged from 6.10 ± 0.10 to 6.40 ± 0.35, 6.16 ± 0.47 to 6.55 ± 0.44 and 6.34 ± 0.47 to 6.67 ± 0.10 with respect to soil depths 0-30 cm, 30-60 cm and 60-90 cm, respectively. Of the all soil depth gradients of 0-30 cm, 30-60 cm and 60-90 cm, the highest soil pH was found in Ahwa (6.10 ± 0.52, 6.16 ± 0.47 and 6.34 ± 0.47 respectively) and was followed by Saputara (6.10 ± 0.10, 6.34 ± 0.05 and 6.67 ± 0.10) and the least value was observed in Waghai (6.40 ± 0.35, 6.53 ± 0.38 and 6.59 ± 0.35, respectively) (Table 2).

The electric conductivity of the soil varied in different locations, soil EC increased with the increase in depth of soil. The soil EC ranged from 0.17 ± 0.03 to 0.30 ± 0.02, 0.20 ± 0.02 to 0.36 ± 0.03 and 0.25 ± 0.02 to 0.41 ± 0.02Sm^{-1} with respect to soil depths0-30 cm, 30-60 cm and 60-90 cm, respectively. Relatively at all soil depth, highest soil EC was found in Mahal (0.30 ± 0.02, 0.36 ± 0.03 and 0.41 ± 0.02Sm^{-1}, respectively) followed by Waghai (0.32 ± 0.02, 0.36 ± 0.01 and 0.40 ± 0.01Sm^{-1}, respectively) (Table 2). The least EC value was in Ahwa (0.17 ± 0.03, 0.20 ± 0.02 and 0.25 ± 0.02Sm^{-1}, respectively).

The soil organic carbon also increased with an increase in depth of soil and the highest value was observed in 0-30 cm layers. In all locations studied, organic carbon value ranged from 0.77 ± 0.04 to 0.86 ± 0.01, 1.37 ± 0.04 to 1.42 ± 0.01 and 1.76 ± 0.02 to 1.83 ± 0.03 $tCha^{-1}$ at soil depths of 0-30 cm, 30-60 cm and 60-90 cm, respectively. Of all depth gradients of 0-30 cm, 30-60 cm and 60-90 cm, higher average organic carbon content was found in Saputara (0.82 ± 0.03, 1.42 ± 0.01 and 1.83 ± 0.03$tCha^{-1}$, respectively) followed by Mahal (0.86 ± 0.01, 1.39 ± 0.01 and 1.74 ± 0.02$tCha^{-1}$ respectively) and the least was in Waghai (0.77 ± 0.04, 1.37 ± 0.04 and 1.79 ± 0.03$tCha^{-1}$, respectively) (Table 2).

Meanwhile, the available nitrogen decreased with an increase in soil depth. In all locations nitrogen ranged from 275.14 ± 37.98 to 334.92 ± 31.08, 113.89 ± 12.47 to 218.59 ± 22.46 and 103.55 ± 25.20 to 174.99 ± 39.14 $Kgha^{-1}$ with soil depths of 0-30 cm, 30-60 cm and 60-90 cm respectively. Relatively at all soil depths highest nitrogen content was found in Saputara (334.92 ± 31.08, 218.59 ± 22.46 and 174.99 ± 39.14 $Kgha^{-1}$ respectively) followed by Waghai (312.68 ± 14.26, 201.13 ± 20.95 and 149.58 ± 14.03 $Kgha^{-1}$ respectively). The least available nitrogen was found in Mahal (328.67 ± 17.08, 113.89 ± 12.47 and 103.55 ± 25.20 $Kgha^{-1}$ respectively) (Table 2).

Similar to nitrogen, phosphorus and potash decreased with increase in depth of soil. For entire locations phosphorus ranged from 32.67 ± 4.94 to 53.44 ± 10.40, 24.95 ± 3.54 to 42.95 ± 4.27 and 20.60 ± 3.45 to 37.07 ± 6.29 $Kgha^{-1}$ and at potash ranged from 349.30 ± 45.98 to 421.66 ± 47.53, 281.69 ± 37.71 to 342.87 ± 36.97 and 214.76 ± 24.53 to 239.56 ± 22.42 $Kgha^{-1}$ at soil depths 0-30 cm, 30-60 cm and 60-90cm, respectively (Table 2). With regard to forest range, the highest phosphorus was recorded in Chikhali (53.44 ± 10.40, 42.95 ± 4.27 and 37.07 ± 6.29 $Kgha^{-1}$ at 0-30, 30-60, 60-90cm, respectively) followed by Saputara (41.02 ± 4.14, 36.70 ± 5.48 and 32.41 ± 5.40 $Kgha^{-1}$) and the least phosphorus was found in Waghai (32.67 ± 4.94, 24.95 ± 3.54 and 20.60 ± 3.45 $Kgha^{-1}$). Whereas, highest available potash recorded was found in Mahal (421.66 ± 47.53, 342.87 ± 36.97 and 228.20 ± 19.67 $Kgha^{-1}$) followed by Saputara (414.38 ± 27.07, 332.21 ± 17.10 and 233.02 ± 15.00 $Kgha^{-1}$). The least available potash was found in Ahwa (349.30 ± 45.98, 281.69 ± 37.71 and 214.76 ± 24.53 $Kgha^{-1}$) (Table 2).

DISCUSSION

Forest management activities, species composition, and canopy characteristics within a soil series are the prevalent factors that not only influence soil properties but also modify the physical and chemical properties of soils that is suitable for growth (Kiser et al., 2008). Vegetation and soil factor shows dependence on each other but vegetation showed a strong effect on the vertical dimensions of the soil profile (Rathod and Devar (2003); Meric et al. (2010); Gairola et al. (2012)). Hence three different depths of soil i.e. 0-30, 30-60 and 60-90 cm were taken into account for analysis. Result of analysis showed the conformation with the work done by (Schlesinger and Pilmanis (1998); Kumar et al. (2014b); Pilania et al. (2015). For soil aggregates at different depths the percentage of particles varied. In the present study during physical analysis water holding capacity and porosity were higher at upper layer of soil. Misha et al. (1989) reported that with increase of organic carbon and aluminium (Al) oxide of soil may increase the pH dependent acidity occupied more than 96.44 % of total acidity in soil due to inorganic component, especially oxides of Fe and Al, which are usually associated with soil clay and the expose octahedral Fe/Al carrying residual charge in the surface clay crystal. Available of nitrogen, phosphate and potash have higher content at upper layers of soil at study area. Indeed, pH increased with depth while EC decreased with depth. Concentration of nutrients are more at the soil surface and attenuate with depth (Rathod and Devar (2003); Meric et al. (2010); Kulkarni et al. (2011); Gairola et al. (2012); Pilania and Panchal (2013a, 2013b); Karlikar and Solanki (2014); Pilania et al. (2015).

The results revealed the variation in physical and chemical properties of soil across a single mapping unit because the behavior of soil chemical properties i.e. both macro and micronutrient is very complex because numerous processes operate simultaneously and due to various biological and chemical processes operating simultaneously and differ continuously over a period of time (Hesterberg, 1998). Additionally, the change in nutrient concentration and their distribution is the great concern as it not only affects the plant nutrition but also influences the environmental quality. However, based on information about tree species and management activities in each soil individuals, it is very difficult to tract out nutrient cycles for each nutrient and particular factors that influences soil macro and micro nutrients.. Variation in soil nutrients across a single series is the result of combined factors of natural and human driven activities (Bhandari and Ficklin, 2009). It is difficult to point out one factor which is responsible for a particular nutrient at the particular location that makes significant difference as compared to their content in the other sites. However, nutrient dynamics at each site is the main driving force for determining physical and chemical properties of soil within a soil mapping unit at the different locations and depth increments.

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REFERENCES

Bhandari, B. and Ficklin, R. L. 2009. Characterizing the Variability of Physical and Chemical Properties across the Soil Individuals Mapped as Amy Silt Loam Soils in Southeastern *Arkansas. J. the Arkansas Academy of Science*. **63:** 34-43.

Ceyhun, Sezgin, M. and Dolarshan, M. 2010. Evaluation of Soil properties and flora under afforestation and natural forest in semi and climate of Central Anatolia, *Env. Biology*. **31:** 21-31.

Everard, M. 2004. Investing in sustainable catchments. *Science of the Total Environment*. **324:** 1-24.

Hesterberg, D. 1998. Biogeochemical cycles and processes leading to change in mobility of chemicals in soils. *Agriculture, Ecosystems and Environment*. **67:** 121-33.

Jackson, M. L. 1973. Soil Chemical Analysis. *Prentice Hall of India Pvt. Ltd., New Delhi, India*.

Karia, J. P. and Kiran, S. 2004. Effect of municipal solid waste on the characteristics of soil. *Pollution Research*. **29(1):** 37-41.

Karlikar, B. H. and Solanki, H. A. 2014. Estimation of micronutrients and Physico-Chemical analysis of soils of Gandhinagar district, Gujarat, India. *Life Sciences Leaflets*. **48:** 49-54.

Kiser, L. C., Kelly, J. M. and Mays, P. A. 2008. Changes in forest soil carbon and nitrogen after a thirty-year interval. *Soil Science Society of America J.* **73:** 647-53.

Kulkarni, A. N., Balkhande, B. D., Waghmare, B. D., Ratnakar, P. U. and Karwate, V. S. 2011. Studies of some phtsico-chemical factors of Teak forest soil from Kinwat area, Nanded, Maharashtra. *The Bioscan*. **6(3):** 437-438.

Kumar, V. 2015. Impact of Non Timber Forest Produces (NTFPs) on food and livelihood security: An economic study of tribal economy in Dang's district of Gujarat, India. *International J. Agriculture, Environment and Biotechnology*. **8(2):** 387-404.

Kumar, V., Babu, S., Revale, A. K., Meena, R. K., Ranjan, M. K. and Desai, B. S. 2014a. Cultivation of medicinal plants in natural ecosystem in Gujarat (India): constraints and conservation need. *J. Plant Development Sciences*. **6(3):** 425-435.

Kumar, V., Bimal, S. D. and Ajeesh, R. 2013. Ecology of Rare and Endangered plant species of Dang's Forest, South Gujarat. *LAP LAMBERT Academic Publishing, Germany*.

Kumar, V., Kumar, S., Jha, S. K. and Jijeesh, C. M. 2014b. Influence of de-oiled seed cakes on seedlings performance of East Indian Rosewood (*Dalbergia latifolia* Roxb.). *Soil Environment*. **33(2):** 169-174.

Meric, C., Ender, M. and Meric, K. 2010. Comparative study on soil properties in a picnic and undisturbed area of Belgrad forest Istanbul. *J. Env. Biology*. **31:** 125-128.

Misra, U. K., Satapathy, S. and Panda, N. 1989. Characterization of some acid soils of Orissa-I. Nature of soil acidity. *Soil Science Society of America Proceedings*. **37:** 22-28.

Norris, J. M. 1970. Multivariate methods in the study of soils. *Soil Fert.* **33:** 313-318.

Olsen, S. R., Cole, C. V., Watanable, F. S. and Dean, L. A. 1954. Estimation of available phosphrous in soils by the extraction with sodium biocarbonate. *USDA, Circ.* p. 939.

Pati, S., Thingujam, U, Badole, S. P., Pal, B., Das, H. and Saha, A. K. 2014. Nature and distribution of soil acidity in different land use pattern of Terai region of west Bengal. *The Ecoscan*. **8(3&4):** 353-357.

Pilania, P. K. and Panchal, N. S. 2013a. Soil analysis at Little Rann of Kachchh in Maliya Tehsil of Morbi district of Saurashtra region of Gujarat state in India. *Life Sciences Leaflets*. **12:** 30-41.

Pilania, P. K. and Panchal, N. S. 2013b. Vegetation analysis at Little Rann of Kachchh in Mallya Tehsil of Gujarat state in India. *J. Basic and Applied Biology*. **7:** 6-10.

Pilania, P. K., Panera, N. M., Vaghasiya, P. M., Mirani, M. K. and

Panchal, N. S. 2015. Analysis of soil at great Rann of Kutch of Gujarat state in Western India. *Life Sciences Leaflets*. **60:** 61-65.

Piper, C. S. 1960. Soil and Plant Analysis. *Hans Publication, Bombay*.

Rathod, R. and Devar, K. V. 2003. Effect of different plantations on soil physical properties. *Karnataka J. Agricultural Science*. **16(3):** 487-488.

Roades, C. C. 1996. Single-tree influences on soil properties in agroforestry: lessons from natural forest and savanna ecosystems. *Agroforestry System*. **35(1):** 71-94.

Schlesinger, W. H. and Pilmanis, A. M. 1998. Plant-soil interactions in deserts. *Biogeochemistry*. **42:** 169-187.

Schoenholtz, S. H., Van Miegroet, H. and Burger, J. A. 2000. A review of chemical and physical properties as indicators of forest soil quality: challenges and opportunities. *Forest Ecology and Management*. **138:** 335-356.

Singh, G., Singh, B., Kuppusamy, V. and Bala, N. 2002. Variations in foliage and soil nutrient composition in *Acacia tortilis* plantation of different ages in North-Western Rajasthan. *Indian Forester*. **128:** 514-521.

Sumeet Gairola, S., Sharma, C. M., Ghildiyal, S. K. and Suyal, S. 2012. Chemical properties of soils in relation to forest composition in moist temperate valley slopes of Garhwal Himalaya, India. Environmentalist. *Springer Science Business Media,* New York.

Tansley, A. G. 1949. Introduction to plant ecology, gorge Alien unwin Ltd, Merseum Street, London.