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Association of Soil Parameters with Various Age Classes of Forests of Mukundpur, Satna, Forest Division, Madhya Pradesh, India

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: This forest area was susceptible to illicit felling, encroachment and illicit mining. From this problem the forests are changing from stocked - under stocked - blank forests. The majority of the area are blank and under stocked category. To re-vegetate the blank and under stocked area into stocked forests, the soil parameters in the study area were needed to be studied in detail. In the present study the associations of soil parameters like pH, electrical conductivity, availability of major nutrients (nitrogen, phosphorous and potassium) and micro nutrients like (copper, manganese, iron and zinc) with various age classes of forests were analyzed.
Study Design: Stratified systematic random sampling.
Place and Duration of Study: Study area was the forest area of 111.55 km^2 of Mukundpur range of Satna Forest division, Madhya Pradesh, India. Field work was carried out during October 2015 to January 2016.
Methodology: The vegetation sampling had been done to assess the forest resource survey. Stratified systematic random sampling method was used for sampling the vegetation. The minimum numbers of sample points were calculated using statistical formula. The 151 sample points at 30"x 30" were selected on safer side with the help of GPS. Half kg of soil sample was collected from central quadrat from the depth of 30 cm from the sample point and air-dried under shade. These

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samples were sent to soil testing lab Rewa to assess the soil parameters pH, electrical conductivity, organic carbon, available nitrogen, available P_2O_5, available K_2O and micronutrient analysis for availability of zinc, iron, manganese and copper. The Microsoft access program was developed to evaluate the above soil parameters in various age classes of forests. Age classes of forest are defined as, Mature: where average girth of forest trees is more than 120 cm, Middle age: where the average girth of trees of a particular forest stands between 61-120 cm, Young age: where average girth of trees of particular stand is below 60 cm.

Results: Results of individual soil parameters on various age classes of forests were summarized below:

The average value of pH in different age classes did not change significantly with average value of pH of the study area. The electrical conductivity within encroachment and blank category significantly changed but in medium and young age classes it did not differ significantly with average electrical conductivity of the study area. In encroachment and blank organic carbon content and available nitrogen were significantly higher but in medium and young age classes these parameters did not change significantly with the average value of organic carbon content and available nitrogen of the study area. The average value of available phosphorous in blank and young age classes did not change significantly but in encroachment and medium young age class it was significantly higher than the average value of available phosphorous of the whole study area. The average value of available K_2O in encroachment, blank and young age class did not change significantly but it changed significantly in medium age class with average K_2O value of study area. Except the encroachment category, the average zinc and iron value in blank, medium and young age classes did not change significantly with average value of the study area. The average value of Mn in encroachment and blank varied significantly but in medium and young category it did not change significantly with the average value of the study area. The average values of Cu with in Blank and young age classes did not change significantly but it had changed significantly in encroachment in medium age class with average value of the study area.

The results of combined effects of pH, EC, Organic Carbon and combined impact of nitrogen, P_2O_5 and K_2O **(**macro nutrients**)** did not have significant association within various age classes of study area. The results of combined effects of Zn, Fe, Mn and Cu did not have significant association within various age classes of study area.

Conclusion: The effects of pH, electrical conductivity and organic carbon were not significant in age classes of study area either individually or jointly. The available nitrogen did not play significant role in age class formation of forest but P_2O_5 and K_2O did make significant impact on medium age classes individually, but the combined effects of nitrogen, P_2O_5 and K_2O (macro nutrients) did not have significant association within various age classes of study area. Individually the Zn, Fe and Mn did not play significant impact on age class formation of the forest, though Cu is significant in medium age classes. The overall impacts of Zn, Fe, Mn and Cu did not have significant association within various age classes of study area.

Keywords: Age class; pH; electrical conductivity; organic carbon content; macro nutrients and micro nutrients.

1. INTRODUCTION

Forests are large tracts of uncultivated lands occupied by trees, shrubs, herbs and other vegetation along with insects and animals, large and small, and microorganisms interacting together and remaining in a dynamic equilibrium with their a biotic environments. Forests cover almost 30% of the world's ice-free land [1] and are the major source of biodiversity. Forests perform important ecological functions such as regulation of climate, sequestration of carbon, biogeochemical cycling etc. Carbon is captured in tree biomass and in forest soils [2]. Forests account for approximately 30% of terrestrial land cover [3] and store about 45% of the carbon in terrestrial ecosystems [4].

As a source of biodiversity India ranks amongst one of the 12 mega biodiversity countries of the world and harbors 17,000 flowering plant species. It accounts for 8% of the global biodiversity with only 2.4% of the total land area of the world [5,6,7].

The study area was also northern tropical dry deciduous mixed forest types with some patches of southern tropical dry deciduous teak forests situated in Mukundpur range of Satna district, Madhya Pradesh, India. The head quarter of

Mukundpur range is in Mukundpur village. This range has geographical area of 589.71 km2 with forest area of 111.55 km2.

This forest area was susceptible to illicit felling, encroachment and illicit mining. The forests of the Mukundpur range have been changing from stocked - under stocked - blank forests. The majority of the area are blank and under stocked category. Some of the area was also encroached for agricultural purposes. Due to topography, some of the area was also erosion prone. This area of Mukundpur range also was surrounded by mining areas of bauxite, limestone. The nearby located cement factories were always in search of new areas, besides exploiting existing known areas. Thus area was encountering impact of temperature rise, industrialization, desertification, shifting in the growing seasons of plants, loss of pollinators and seed dispersers, causing extinction of precious plants. Similarly the forests were more prone to developmental activities specially widening of roads. Thus area of Mukundpur forest was under high ecological stress and forests disturbances.

To understand the ecology of disturbed forests some of the literatures were surveyed to know the effect of degradation of forests on the various forest soil parameters. The reviews of literatures in the study area did not show any significant work. Though, on global level contribution of some of the reviews of the literature were discussed. Zhu and Liu [8] had made the research on forest disturbance ecology, especially on the main ecological processes or the consequential results of disturbed forests, including the change of biodiversity, soil nutrient and water cycle and carbon cycle, regeneration mechanism of disturbed forests and so on. Forests have several carbon pools vegetation, dead wood and litter, soil organic matter, and the humus. At the global level, 19% of the carbon in the earth's biosphere is stored in plants and 81% in the soil. In all forests, tropical, temperate, and boreal together, approximately 31% of the carbon is stored in the biomass and 69% in the soil. In tropical forests, approximately 50% of the carbon is stored in the biomass and 50% in the soil [9].

Tewari et al. [10] had analyzed the physico-chemical properties of soils from different land use systems viz., agriculture, olericulture and two dominant forest types (oak; Quercus leucotrichophora and pine; Pinus roxburgii) in Uttarakhand, India. Some physico-chemical parameters were selected as indicator of soil quality and were investigated by [11]. Zaman et al. [12] had studied under the selected different land use system in Dimoria Development Block under Kamrup District of Assam India. Chandra et al. [13] had discussed about the temperate and dry deciduous forest covers major portion of terrestrial ecosystem in India. Grigal and Vance [14] reported about influence of soil organic matter on forest productivity. Mohd et al. [15] studied about relationship between soil pH with selected soil biological and chemical properties.

Looking towards the blank and under stocking status of the forest of the study area it was necessary to re-vegetate the forest area, so that blank and under stocked area should be converted into stocked forests. For that the soil parameters in the study area were needed to be studied in detail to associate forest ecology with soil ecology. Thus in the present study the associations of soil parameters like pH, electrical conductivity, availability of major nutrients (nitrogen, phosphorous and potassium) and micro nutrients like (copper, manganese, iron and zinc) with various age classes of forests were analyzed.

2. MATERIALS AND METHODS

The area lies between north latitude of 24011'35'' to 24026'25'' and east longitude of 8106'35'' to 81022'20''. The map of the study area is shown in Fig. 1. The forest area of this range exists in 7 forest blocks namely Mand, Govindgarh extension, Papra, Jhinna, Sarhai, Kokahansar and Mankesar. The forest blocks of Govindgarh extension and papra extend in Satna and Rewa forest districts. The part of Mankesar forest block lies in submerged area of Bansagar dam. Northern boundary lies with Beehar River demarcating Satna and Rewa district. Eastern boundary lies mainly with the district boundaries bifurcating Rewa and Satna districts. The famous Charaki ghati forms one of its boundaries. Southern boundary lies mainly with submerged area of Son River and it extends to district boundaries of Shahadol and Satna districts. The major study area has northern tropical dry deciduous mixed forest types with some patches of southern tropical dry deciduous teak forests especially in Mand reserve. The soil in study area has the origin of Vindhyan formation and it consists of materials from sand stone, limestone and shale. The average annual rainfall in study area was noticed from 354.1 mm to 1748.4 mm with mean annual rainfall of 1074.26 mm. The area receives nearly 51 rainy days in year. South western monsoon plays the active role of precipitation in study area starting form middle of June month. The average highest daily temperature ranges within 24.06°C to 41.73°C with mean temperature of 32.24°C. The highest daily temperature recorded was 47.7°C Similarly the average lowest daily temperature was 8.85°C to 27.72°C with minimum daily temperature of 1.7°C the minimum temperature varies in the months from November to February.

For the assessment of forest resource survey of Mukundpur range, the vegetation sampling was done for the trees, shrubs, herbs, climbers, grasses and tubers. Stratified systematic random sampling method was used for sampling the vegetation [16]. For determining minimum number of sample points, the formula used is $〚n=z〛^2\ pq/E^2$ where E= difference between population proportion mean and sample proportion average, p = population proportion, q= 1- p, z=1.96 for a level of significance of 95% [17].

Based on the secondary data from Mukundpur range and Satna forest division, the sample size for various tree parameters i.e. number of trees per hectare, volume per hectare and established regeneration per hectare was calculated at 10% error (E) between population and sample proportion at 95% level of significance keeping in view time and other resources [18].

Minimum 95 numbers of sample points were calculated from the above formula to assess the vegetation. The forest maps of Mukundpur range on survey of India topo sheet is of the scale of 1:15000.

The grids at 35"x 35" and 30"x30" intervals are drawn by trial and error, for systematic random sampling. For drawing the grids, GIS software is used. With this software 35"x 35" and 30"x30" grids are drawn on the map of Mukundpur forests range, so that criteria for minimum number of 95 grids are achieved. The 111 and 151 random points were recorded on above grid. The 151 sample points at 30"x 30" were selected on safer side, so that points may fall in river bed, submergence and encroachments to maintain minimum criteria of 95 numbers. The longitudes and latitudes of 151 points were noted and listed from topo sheets. Out of 151 points, 12 points are on encroachment, 67 points are on blanks, 10 points are on medium age class, 54 points are on medium age class and remaining 8 points are on submerged areas of son river reservoir.

At each sample points, the layout of sample plot of 0.16 hectare with 9 quadrats of 2m x 2m on ground as shown in figure 2 was done with the help of prismatic compass [16]. At these points recording of data of the girth and species of the trees, along with species of shrubs, climbers and tubers (numbers) were taken on whole sample plot of 0.16 hectare and data for species of herbs, grasses and established regeneration was recorded at each 9 quadrate of 2m x 2m. Department of Agriculture, Bhopal, Madhya Pradesh, India [19] had suggested the guide lines for collection of soil sample process. From the guide lines suggested by department of agriculture, 0.5 kg of soil sample was collected from central quadrat from the depth of 30 cm from the sample point and air-dried under shade. These air-dried samples had been transferred into a clean cloth bag bearing a slip with mention of grid number, latitude and longitude. These samples were sent to soil testing lab, Rewa to assess the soil parameters pH, electrical conductivity (in mmhos/cm), organic carbon (in %), available nitrogen (in kg/ha), available P2O5 (in kg/ha), available K2O (in kg/ha) and micronutrient analysis for availability of zinc (in ppm), iron (in ppm), manganese (in ppm) and copper (in ppm). The Microsoft Access program was developed to evaluate the above soil parameters in various age classes of forests.

Theses age classes are described by [16] as below. Age of forest crops: Mature: where average girth of forest trees is more than 120 cm, Middle age: where the average girth of trees of a particular forest stands between 61-120 cm, Young age: where average girth of trees of particular stand is below 60 cm. and above 10 cm. Measuring girths of trees below 10 cm was not feasible.

The average value of different soil parameter in different age classes and in whole study area is evaluated and standard error for whole study area is calculated. To assess the association of various soil parameters within various age classes, testing of hypothesis at 5% level of significance is done using Z statistics. The Z value is calculated from the formula given below:

Z cal of particular soil parameter = | (Observed average value of the soil parameter in particular age class - average value of the soil parameter in study area) / Standard error of the soil parameter in study area |

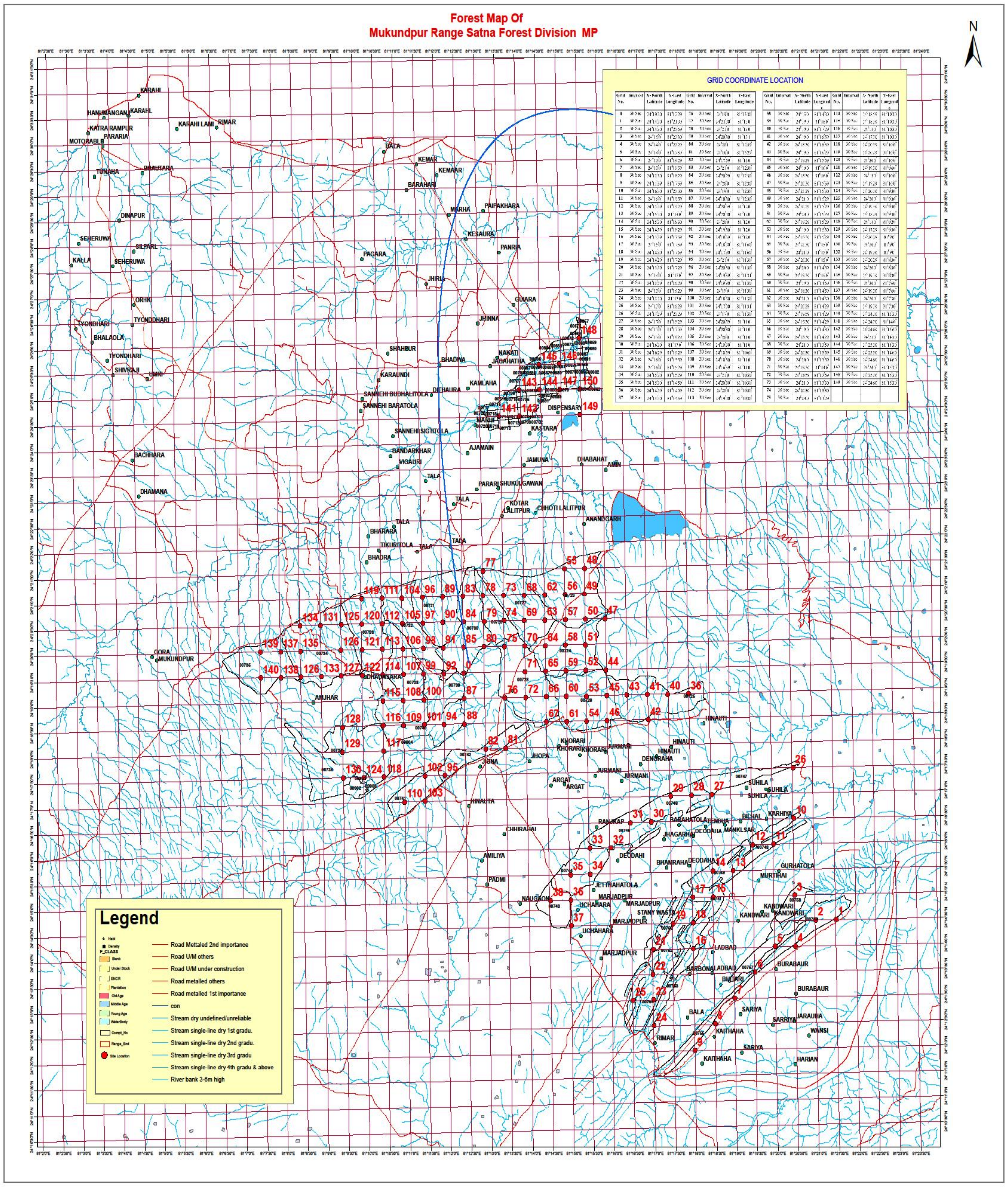

Fig. 1. Map of the Study Area

Each sample points were located on ground with the help of GPS.

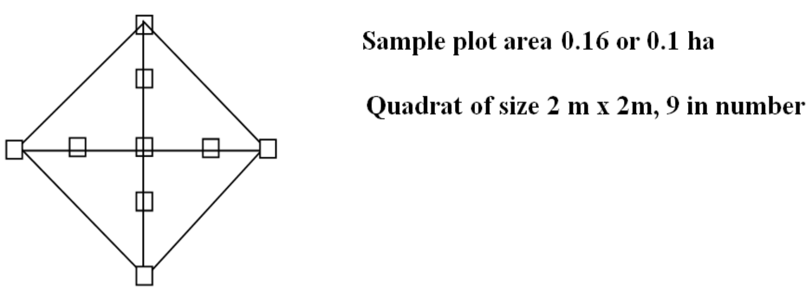

Fig. 2. Sample plot with their Quadrat

At 5% level of significant following hypothesis is formulated:

1. **Null hypothesis (H_0):** There is no significant difference in average value of the soil parameters and average value of the soil parameter of study area.
2. **Alternate hypothesis (H_i):** There is a significant difference in average value of the soil parameters and average value of the soil parameter of study area.

At 5% level of significance, the testing of hypothesis has been done by following decision rules:

1. If $Z_{calculated} < Z_{tabulated}$ Null hypothesis is not rejected. It means there is no significant difference in average value of the soil parameters and average value of the soil parameter of study area.
2. If $Z_{calculated} > Z_{tabulated}$ Null hypothesis rejected. It means there is a significant difference in average value of the soil parameters and average value of the soil parameter of study area.

After calculating Z value of various soil parameters the combined effects of following parameters are studied using χ^2 analysis at 5% level of significance:

1. Combined effect of pH, electrical conductivity and organic carbon within various age classes of study area.
2. Combined effect of Macro nutrient (available N, P_2O_5 and K_2O) within various age classes of study area.
3. Combined effect of Micro nutrient (available Zn, Fe, Mn and Cu) within various age classes of study area.

At 5% level of significant following hypothesis for χ^2 analysis is formulated:

1. **Null hypothesis (H_0)**: There is no significant difference combined effect of above studies within various age classes of study area.
2. **Alternate hypothesis (H_i):** There is a significant difference combined effect of above studies within various age classes of study area.

At 5% level of significance, the testing of hypothesis for χ^2 analysis following decision rules are followed:

1. If $\chi^2_{calculated} < \chi^2_{tabulated}$ Null hypothesis is not rejected. It means There is no significant difference combined effect of above studies within various age classes of study area
2. If $\chi^2_{calculated} > \chi^2_{tabulated}$ Null hypothesis rejected. It means There is a significant difference combined effect of above studies within various age classes of study area

χ^2 is calculated with the formula as $\chi^2_{cal} = \sum \frac{(O-E)^2}{E}$, where O = Observed values and E = Expected Values

3. RESULTS AND DISCUSSION

3.1 Association of Individual Soil Parameters in Various Age Classes

The soil parameters studied were pH, electrical conductivity (mmhos/cm), organic carbon in %, available nitrogen (in kg/ha), available phosphorous and available potassium (in kg/ha), Zn, Fe, Mg, Cu (in ppm). Calculated value of these parameters in various age classes were analyzed and presented in Table 1 of this section.

From the Table 1 the $Z_{calculated}$ for various soil parameters within various age classes of study area was presented below in Table 2 and it was compared with the tabulated value of Z to test the hypothesis at 5% level of significance.

From the Table 2 for results of the study of soil parameters in various age classes of study area were discussed below:

pH: The soil pH influences the rate of nutrients release through its influence on decomposition, carbon exchange capacity and solubility of materials. Further, soil pH influences plant growth by way of improving the soil physical condition and nutrients availability, whereas, high or low pH of nutrient medium has adverse effect on plant growth. The pH of various age classes i.e. encroachments, blanks, medium and young varied from 7.06 to 7.12 with average pH is 7.09. The pH of study area in young and medium age

Table 1. Various soil parameters with in various age classes

Age	pH	EC (mmhos/cm)	O/C (%)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Blank	7.06	0.27	0.66	247.83	38.21	213.03	0.18	4.46	1.66	0.27
Encroachment	7.11	0.35	0.38	178	45.13	202	0.04	1.91	1	0.42
Medium	7.12	0.28	0.64	244.16	34.31	198.42	0.18	5.32	1.31	0.37
Young	7.09	0.28	0.61	235.69	38.83	212.3	0.21	5.06	1.2	0.29
Average	**7.09**	**0.28**	**0.63**	**240.06**	**37.98**	**210.19**	**0.19**	**4.9**	**1.35**	**0.3**
SE	**0.022**	**0.006**	**0.013**	**3.383**	**1.196**	**5.54**	**0.027**	**0.32**	**0.109**	**0.021**

Table 2. Z $_{calculated}$ for various soil parameters within various age classes

Soil parameters	Age classes								Z $_{table}$ at 5% level of significance (one tailed test)
	Blank		Encroachment		Medium		Young		
	Average	Z_{cal}	Average	Z_{cal}	Average	Z_{cal}	Average	Z_{cal}	
pH	7.060	1.360	7.110	0.909	7.120	1.364	7.090	0.000	1.645
EC	0.270	1.667	0.350	11.667	0.280	0.000	0.280	0.000	1.645
O/C	0.660	2.300	0.380	19.200	0.640	0.769	0.610	1.538	1.645
N	247.820	2.293	178.000	16.345	244.160	1.212	235.690	1.292	1.645
P_2O_5	38.210	0.192	45.130	5.978	34.310	3.069	38.830	0.711	1.645
K_2O	213.030	0.513	202.000	1.478	198.420	2.125	212.300	0.381	1.645
Zn	0.180	0.370	0.040	5.560	0.180	0.370	0.210	0.741	1.645
Fe	4.460	1.375	1.910	9.343	5.320	1.313	5.060	0.500	1.645
Mn	1.660	2.840	1.000	3.211	1.310	0.367	1.200	1.376	1.645
Cu	0.270	1.429	0.420	5.714	0.370	3.333	0.290	0.476	1.645

classes was neutral. Results indicated that the average value of pH in different age classes did not change significantly with average value of pH of the study area as $Z_{cal} < Z_{tab}$ (1.645). Thus the pH did not play the significant role within various age classes. It means that age class (young and medium) in the study area with forests and pH of the study area were independent variables. The pH was the important parameter of soil ecology and it might have role in individual plants or vegetation but it did not play any role in girth making formation (less than 60 cm, 61 to 120 cm) of forest trees. The age class of forest stand was parameter of forest ecology while pH is a parameter of soil ecology and it did not have its effect on community level.

Electrical Conductivity: The measure of electrical conductivity shows the total amount of soluble salts present in the soil. It is the most common measure of soil salinity. Average electrical conductivity for soil of study area is 0.28 mmhos/cm. This varies from 0.27 to 0.35 mmhos/cm for various age classes. Results indicated that the electrical conductivity within encroachment and blank category significantly changed with average electrical conductivity of the study area. The electrical conductivity with in medium and young age class did not differ significantly with average value of electrical conductivity of study area. Thus in age class formation of the forest i.e. girth making formation of the forest stand, the electrical conductivity did not play any role but as soon as forest is degraded to blank and encroachment status the electrical conductivity did contribute its significant role. The blank and encroachment status became when various girth classes of the forests were removed due to manmade disturbances as in blank and encroachment areas were devoid of vegetation and only soil ecology remained in picture.

Organic Carbon Content: The level of soil organic matter determines the multiplication of microorganisms and makes the system more dynamic. The observed values of organic matter content in percentage for various age class i.e. encroachment, blank, medium and young categories were 0.38, 0.66, 0.64, and 0.61 respectively with average value of 0.63. The result indicated that in encroachment and blank organic carbon content was significantly higher than the average value of organic carbon content of the study area as $Z_{cal} > Z_{tab}$ (1.645). But in medium and young age class the organic carbon content did not differ significantly with the average organic carbon value of the study area as $Z_{cal} < Z_{tab}$ (1.645). The organic carbon content in forests soil did not have any role in the formation of age class i.e. girth making formation of the forest stand. Thus at community level the organic carbon did not possess any role but when forest area was degraded into blank and encroachment category (breaking of land due to agriculture), the soil organic carbon played significantly at individual level of vegetation.

Available Nitrogen: Nitrogen is an important factor affecting decomposition. The availability of nitrogen is due to the regular addition of plant residues on the soil and decomposition. The organic compounds are converted into inorganic nitrogen by certain bacteria, which can be absorbed by the plants. Results for average value of nitrogen availability for whole forest of study area was 240.06 kg/ha. Results indicated that the average value of available nitrogen was 178.00, 247.820, 244.16 and 235.69 kg/ha in encroachment, blank, medium and young age classes respectively. The average value of available nitrogen in encroachment and blank significantly changed from average value of the available nitrogen of the study area as $Z_{cal} > Z_{tab}$ (1.645). The average value of available nitrogen in medium and young age class did not change significantly with average value of available nitrogen of the study area as $Z_{cal} < Z_{tab}$ (1.645). The nitrogen in forests soil did not have any role in the formation of age class i.e. girth making formation of the forest stand. Thus at community level the nitrogen did not have any role but when forest area was degraded into blank and encroachment category, the soil nitrogen played significantly. Thus as long as forest of the study area maintained the undegraded state, the average value of available nitrogen maintained the average value of study area. As soon as it was converted into blank and encroachment due to degradation, average value of available nitrogen changed significantly. It decreased very significantly when it came to encroachment category.

Available Phosphorous: Phosphorus is an essential constituent of protoplasm. It does not move readily through the soil and is not leached by rain or watering. Phosphorous is absorbed by the plants as H_2PO_4 HPO_4 or PO_4 depending upon soil pH. Most of the total phosphorous is tied up chemically in compound of limited solubility. The results of available phosphorous in kg/ha for study area was 37.98 kg/ha. The average value of available phosphorous in blank and young age classes did not change significantly with average value of available phosphorous of the study area as $Z_{cal} < Z_{tab}$ (1.645). The average value of available phosphorus in encroachment and medium age class was significantly higher than the average value of available phosphorous of the whole study area as $Z_{cal} > Z_{tab}$ (1.645). When there was a breaking of forest land due to agriculture there was a significant increasing available phosphorous. This meant that breaking of land exposes the rocks, soil and geology devoid the vegetation, which had increased the available phosphorous to significant level. As the forest land had changed from encroachment to blank forest, available phosphorus reduced from significant to non significant. As blank forest was developed into young age class, the available phosphorous was reduced and it might be used by plants individually. Again when young stand of forest converted into medium age i.e. girth of average stand of forest increased more than 61 cm, the available phosphorous in soil reduced significantly. Thus it seemed that the phosphorous was the responsible element for improving the average girth class of the forest stand.

Available Potassium: Potassium is an activator of dozens of enzymes responsible for energy metabolism starch synthesis, nitrate reduction and also plays a major role in protection against disease by thickening the other cell walls of plants tissue. Results of available K_2O for study area was 210.190 kg/ha. The average value of K_2O in encroachment, blank, medium and young age classes were 202.00, 213.03, 198.42 and 212.30 kg/ha, respectively. The average value of available K_2O in encroachment, blank and young age class did not change significantly with average K_2O value of study area as $Z_{cal} < Z_{tab}$ (1.645). In medium age class the average value of K_2O did significant change with average value of K_2O of the study area as $Z_{cal} > Z_{tab}$ (1.645). Thus lower average value of available K_2O is the responsible factor for changing into medium age class from young age class. When average girth of forest stand had increased from 60 cm, the available potassium in soil was decreased significantly in higher girth class of forest stand. It seemed that K_2O was used for development of growth of average girth size of forest stand and thus available potassium in soil reduced significantly.

Available Zinc: Zinc, as Zn^{2+}, occurs as an exchangeable cation, is strongly absorbed onto several soil constituents, and is complexed by organic matter. The zinc is required for the photosynthesis. Zinc solubility is low in soils and it forms chelates with organic matter to increase the phytoavailability in mineral soils, but can lead to deficiency in organic soils. The result of the average value of zinc in study area was 0.19 ppm. The average value of zinc in encroachment, blank, medium and young was 0.040, 0.18, 0.18 and 0.21 ppm respectively. The average zinc value in blank, medium and young age classes did not change significantly with average value of the study area as $Z_{cal} < Z_{tab}$ (1.645). But average value of zinc in encroachment category changed significantly with average value of the study area. Results indicated that breaking of forest land resulted in major loss in Zn availability. Hence Zn could play important role in photosynthesis of vegetation in individual plants but it did not play significant role in the formation of average girth of the forest stand i.e. age class formation in a forest.

Available Iron: Iron is weathered from minerals and appears as divalent cations in solutions as such, they are available to plants. The Iron is required as a trace element and required by photosynthesis and for nitrogen metabolism. The result of available Fe for study area was 4.9 ppm. The average value of Fe in encroachment, blank, medium and young age classes was 1.910, 4.460, 5.06 and 5.32 ppm respectively. The average value of Fe in blank, medium and young category did not change significantly with the average value of as $Z_{cal} < Z_{tab}$ (1.645). Thus Fe as a trace element might be required in individual plant but it did not reflect any association in girth formation of forest stands. But average value of Fe in encroachment category varied significantly with average value of the study area as $Z_{cal} > Z_{tab}$ (1.645). Thus breaking of land due to agriculture significantly lowered the Fe content in encroached soil.

Available Manganese: The manganese is weathered from minerals and appears as divalent cations in solution as such, they are available to plants. This element is required in trace amount and required for photosynthesis and other metabolism functions. The results of average observed value of available Mn for study area was 1.35 ppm. The average Mn value for encroachment, blank, medium and young age class was 1.000, 1.660, 1.31 and 1.20 ppm respectively. The average value of Mn in encroachment and blank varied significantly with the average value of the study area as $Z_{cal} > Z_{tab}$

(1.645). Thus when forest area was devoid of vegetation, the role of available manganese appeared. The average value of Mn in medium and young category did not change significantly with average value of study area as $Z_{cal} < Z_{tab}$ (1.645). Thus manganese in girth formation of tree did not contribute in the forest stand.

Available Copper: Copper is released from mineral weathering to the soil solution as Cu^{2+}. This micronutrient cations can be adsorbed onto cation exchange sites. This element is required for other metabolism. It forms chelates with organic matter to increase phyto-availability in mineral soils. The results for study area indicate that average observed value of Cu was 0.30 ppm. The average Cu value for encroachment, blank, medium and young age classes was 0.420, 0.270, 0.37 and 0.29 ppm respectively. The average values of Cu with in blank and young age classes did not change significantly with average value of the study area as $Z_{cal} < Z_{tab}$ (1.645). But average value of Cu in encroachment and medium age class significantly changed with average value of study area as $Z_{cal} > Z_{tab}$ (1.645). When undisturbed land (no breaking of land), the copper did not play any role in girth formation of forest stand (young age) but when average girth of the forest stand increased from young to medium age (greater than 60 cm) the Cu showed its important contribution.

3.2 Association of Combined Soil Parameters (pH, EC, Organic Carbon) in Various Age Classes of Study Area

From Table 2 the Z value of pH, EC and organic carbon various age classes of study area was given in Table 3.

To understand the association about the combined effects of the pH, EC and organic carbon within various age classes of study area, these values are converted into Z scores to maintain the same dimensional unit and hypothesis is done using χ^2 analysis. In Table 3 figure represented in bracket represent the expected Z value.

$\chi^2_{calculated} = 12.577$
Degree of freedom = (4-1) * (3-1) = 6
At 5% level of significance at 6 degree of freedom, $\chi^2_{tabulated} = 12.592$

Since $\chi^2_{cal} < \chi^2_{tabulated,}$ null hypothesis is accepted. Hence combined impact of pH, EC and organic carbon did not have significant association within various age classes of study area. Individual effects of pH, EC and Organic Carbon also did not play the significant role in age classes of study area i.e. these soil parameters did not affect the age class formation of forest either individually or jointly. These parameters were functioning in a land ecosystem as the resultant action of climate and organism on the parent material of the surface of earth. Girth formations of forests were the component of forest ecosystem thus the soil parameter of land ecosystem supports individual plant but it was unable to support the producer component of forest ecosystem. Thus these parameters had the neutral association with forest ecology but these parameters might have interaction of mutualism with in land ecosystem.

3.3 Association of Combined Macro Nutrient of Soil Parameters (N, P_2O_5 and K_2O) in Various Age Classes of Study Area

From Table 2 the Z value of Nitrogen, P_2O_5 and K_2O within various age classes of study area was given in Table 4.

To understand the association about the combined effects of the Nitrogen, P_2O_5 and K_2O within various age classes of study area, these values were converted into Z scores to maintain the same dimensional unit and hypothesis was done using χ^2 analysis. In Table 4 figure represented in bracket represent the expected Z value.

$\chi^2_{calculated} = 6.736$
Degree of freedom = (4-1) * (3-1) = 6
At 5% level of significance at 6 degree of freedom, $\chi^2_{tabulated} = 12.592$

Table 3. Z value of pH, EC and organic carbon within various age classes

Age	pH	EC	O/C	Total
Blank	1.360 (**0.475**)	1.667 (**1.742**)	2.300 (**3.110**)	5.327
Encroachment	0.909 (**2.831**)	11.667 (**10.391**)	19.200 (**18.553**)	31.776
Medium	1.364 (**0.190**)	0 (**0.698**)	0.769 (**1.245**)	2.133
Young	0 (**0.137**)	0 (**0.503**)	1.538 (**0.898**)	1.538
Total	**3.633**	**13.334**	**23.807**	**40.774**

Table 4. Z value of N, P_2O_5 and K_2O within various age classes

Age	N	P_2O_5	K_2O	Total
Blank	2.293 (**1.781**)	0.192 (**0.838**)	0.513 (**0.379**)	2.998
Encroachment	16.345 (**14.139**)	5.978 (**6.654**)	1.478 (**3.007**)	23.801
Medium	1.212 (**3.806**)	3.069 (**1.791**)	2.125 (**0.809**)	6.406
Young	1.292 (**1.416**)	0.711 (**0.667**)	0.381 (**0.301**)	2.384
Total	**21.142**	**9.950**	**4.497**	**35.589**

Table 5. Z value of Zn, Fe, Mn and Cu within various age classes

Age	Zn	Fe	Mn	Cu	Total
Blank	0.370 (**1.105**)	1.375 (**1.967**)	2.840 (**1.223**)	1.429 (**1.719**)	6.014
Encroachment	5.560 (**4.378**)	9.343 (**7.792**)	3.211 (**4.847**)	5.714 (**6.810**)	23.828
Medium	0.370 (**0.989**)	1.313 (**1.760**)	0.367 (**1.095**)	3.333 (**1.539**)	5.383
Young	0.741 (**0.568**)	0.500 (**1.011**)	1.376 (**0.629**)	0.476 (**0.884**)	3.093
Total	**7.041**	**12.531**	**7.794**	**10.952**	**38.318**

Since $\chi^2_{cal} < \chi^2_{tabulated}$, null hypothesis is accepted. Hence combined impact of Nitrogen, P_2O_5 and K_2O (macro nutrients) did not have significant association within various age classes of study area. Except encroachment and blank category class, individually available nitrogen did not play significant role in age class formation of forest but P_2O_5 and K_2O did make significant impact on medium age classes individually. These parameters were functioning in a land ecosystem as the resultant action of climate and organism on the parent material of the surface of earth. Girth formations of forests stand are the producer components of forest ecosystem thus the soil parameter P_2O_5 and K_2O of land ecosystem supports the girth formation of forest stands of forest ecosystem. These two elements were the connecting links between forest ecology and soil ecology.

3.4 Association of Combined Micro Nutrient of Soil Parameters (Zn, Fe, Mn and Cu) in Various Age Classes of Study Area

From Table 2 the Z value of Zn, Fe, Mn and Cu within various age classes of study area was given in Table 5.

To understand the association about the combined effects of the Zn, Fe, Mn and Cu within various age classes of study area, these values were converted into Z scores to maintain the same dimensional unit and hypothesis was done using χ^2 analysis. In Table 5 figure represented in bracket represent the expected Z value.

$\chi^2_{calculated} = 8.673$
Degree of freedom = (4-1) * (4-1) = 9

At 5% level of significance at 9 degree of freedom, $\chi^2_{tabulated} = 16.919$

Since $\chi^2_{cal} < \chi^2_{tabulated}$, null hypothesis is accepted. Hence overall impact of Zn, Fe, Mn and Cu did not have significant association within various age classes of study area. Individually the Zn, Fe and Mn did not play significant impact on age class formation of the forest, though individual effect of Cu was significant in medium age classes. Girth formations of forests were the component of forest ecosystem thus the soil parameter of land ecosystem supports individual plant but it was unable to support the producer component of forest ecosystem. Thus these parameters had the neutral association with forest ecology but these parameters might have interaction of mutualism with in land ecosystem.

4. CONCLUSION

The effects of individual soil parameters on various age classes of forests were summarized below:

The pH and electrical conductivity did not play the significant role within various age classes. The pH was the important parameter of soil ecology and it may have role in individual plants or vegetation but it did not play any role in girth making formation (less than 60 cm, 61 to 120 cm) of forest trees. In age class formation of the forest i.e. girth making formation of the forest stand, the electrical conductivity did not play any role but as soon as forest was degraded to blank and encroachment status the electrical conductivity did contribute its significant role. The blank and encroachment status became when various girth classes of the forests were removed due to manmade disturbances as in blank and encroachment areas were devoid of vegetation.

In medium and young age class the organic carbon content did not differ significantly with the average organic carbon value of the study area. The organic carbon content in forests soil did not have any association in the formation of age class. At community level the organic carbon did not possess any role but when forest area was degraded into blank and encroachment category (breaking of land due to agriculture), the soil organic carbon reduced significantly at individual level of vegetation.

The average value of available nitrogen in medium and young age class did not change significantly with average value of available nitrogen of the study area. The nitrogen in forests soil did not have any role in the formation of age class i.e. girth making formation of the forest stand. Thus at community level the nitrogen did not have any role but when forest area was degraded into blank and encroachment category, the soil nitrogen played the significant role. As long as forest of the study area maintained the undegraded state, the average value of available nitrogen maintained the average value of study area. As soon as it was converted into blank and encroachment due to degradation, average value of available nitrogen changes significantly. It decreased very significantly when it came to encroachment category.

The average value of available phosphorus in medium age class and encroachment category significantly was higher than the average value of available phosphorous of the whole study area, but blank and young age class this parameter did not affect. When there was a breaking of forest land due to agriculture there was a significant increasing available phosphorous. This meant that breaking of land exposes the rocks, soil and geology devoid the vegetation, which had increased the available phosphorous to significant level. As the forest land had changed from encroachment to blank forest, available phosphorus reduced from significant to non significant status. As blank forest was developed into young age class, the available phosphorous was reduced and it might be used by plants individually. Again when young stand of forest converted into medium age i.e. girth of average stand of forest increased more than 61 cm, the available phosphorous in soil reduced significantly. Thus it seemed that the phosphorous was the responsible element for improving the average girth class of the forest stand.

In medium age class the average value of K_2O showed the significant change with average value of K_2O of the study area, but in encroachment, blank and young age class this parameter did not make significant impact. The lower average value of available K_2O was the responsible factor for changing into medium age class from young age class. The lower average value of available K_2O was the responsible factor for changing into medium age class from young age class. When average girth of forest stand had increased from 60 cm, the available potassium in soil was decreased significantly in higher girth class of forest stand. It seemed that K_2O was used for development of growth of average girth size of forest stand and thus available potassium in soil reduced significantly.

The average zinc and Fe values in blank, medium and young age classes did not change significantly with average value of the study area. But average value of zinc and Fe in encroachment category changed significantly with average value of the study area. The breaking of forest land resulted in major loss in Zn and Fe availability. Hence Zn and Fe could play important role in photosynthesis of vegetation in individual plants but it did not play significant role in the formation of average girth of the forest stand i.e. age class formation in a forest.

The average value of Mn in medium and young category did not change significantly with average value of study area. The manganese did not contribute in girth formation of tree in the forest stand.

The average value of Cu in medium age class significantly changes with average value of study area, but this soil parameter did not affect significantly in younger age class. When undisturbed land (no breaking of land), the copper did not play any role in girth formation of forest stand (young age) but when average girth of the forest stand increased from young to medium age (greater than 60 cm) the Cu showed its important contribution.

The combined impacts of pH, EC and organic carbon did not have significant association within various age classes of study area. Individual effects of pH, EC and Organic Carbon also did not play the significant role in age classes of study area i.e. these soil parameters did not affect the age class formation of forest either individually or jointly. These parameters were functioning in a land ecosystem as the resultant action of climate and organism on the parent material of the surface of earth. Girth formations of forests were the component of forest ecosystem thus the soil parameter of land ecosystem supports individual plant but it was unable to support the producer component of forest ecosystem. Thus these parameters had the neutral association with forest ecology but these parameters might have interaction of mutualism with in land ecosystem.

The combined impact of N, P_2O_5 and K_2O **(**macro nutrients**)** did not have significant association within various age classes of study area. Except encroachment and blank category class, individually available nitrogen did not play significant role in age class formation of forest but P_2O_5 and K_2O did make significant impact on medium age classes individually. These parameters were functioning in a land ecosystem as the resultant action of climate and organism on the parent material of the surface of earth. Girth formations of forests stand were the producer components of forest ecosystem thus the soil parameter P_2O_5 and K_2O of land ecosystem supports the girth formation of forest stands of forest ecosystem. These two elements were the connecting links between forest ecology and soil ecology.

The overall impact of Zn, Fe, Mn and Cu did not have significant association within various age classes of study area. Individually the Zn, Fe and Mn did not play significant impact on age class formation of the forest, though individual effect of Cu was significant in medium age classes. Girth formations of forests were the component of forest ecosystem thus the soil parameter of land ecosystem supports individual plant but it was unable to support the producer component of forest ecosystem. Thus these parameters had the neutral association with forest ecology but these parameters might have interaction of mutualism with in land ecosystem.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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