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Soil physico-chemical properties under some dominating vegetations of coastal Odisha

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Abstract
An analysis of soil physico-chemical properties and growth parameters under some dominating vegetations was done during July 2018 - June 2019. The experiment was laid out in a Randomized Block Design having seven naturally dominating tree species such as *Shorea robusta, Tectona grandis, Mallotus philippensis, Xantolis tomentosa, Acacia nilotica, Bambusa bambos* and *Bambusa bambos* (Dwarf) with three replications. The analysis revealed that soils under *Acacia nilotica* possessed highest bulk density (1.42 g/cm^3) whereas *Mallotus philippensis* had lowest (1.27g/cm^3). Particle density of soil under *Xantolis tomentosa* was recorded highest (2.61 g/cm^3) while *Bambusa bambos* (Dwarf) registered minimum (2.44 g/cm^3). Maximum pH and electrical conductivity were resulted under *Acacia nilotica* (8.20 and 0.045 dSm^{-1} respectively) whereas minimum pH under *Shorea robusta* (5.89) and minimum EC under *Bambusa bambos* (Dwarf) (0.005 dSm^{-1}). The soil organic carbon under *Bambusa bambos* claimed highest (13.85 g/kg soil) while *Shorea robusta* secured minimum (5.44 g/kg soil). With regard to growth, *Tectona grandis* excelled in height (37.35m) whereas *Bambusa bambos* (Dwarf) achieved minimum height (3.95 m). Average clump diameter of *Bambusa bambos* was significantly higher (108 cm) and lowest value (12.61 cm) was recorded under *Xantolis tomentosa*. *Bambusa bambos* generated highest basal area per hectare (47.53 m^2/ha) while *Xantolis tomentosa* registered the lowest (2.27 m^2/ha). The results indicated that dominance of different vegetations within the same climatic condition is due to variation in soil properties and those properties should be taken into account for recommending the suitable species for a particular site.

Keywords: Soil property, dominant vegetation, coastal Odisha

Introduction
The variation in forest types from place to place results because of variation of factors of locality. The factors of locality include climatic factors like solar radiation, rainfall and wind, edaphic factors which include physical and chemical properties of soil, topographic factors like configuration of land surface, altitude, slope and biotic factors which consist of all flora and fauna of that area. The edaphic factors are the physico-chemical properties of soil that affect the local environment significantly. Different ecologists have given emphasis to edaphic factors in the global and regional distribution of organisms. Discontinuities in these edaphic factors have contributed significantly to various patterns of diversity we see in the world. Tree richness was closely related to soil status of an area as soil provides nutrients needed for their survival [1]. Relationships between different soil properties and plant species richness had been studied in various habitats of grassland [2], in savanna communities [3] as well as in tropical rainforests [4]. A study in the National Park at Merapoh, Pahang, Malaysia found that vegetation composition patterns were highly correlated with edaphic variables [5]. In another study in Tekam Forest Reserve and Pasoh Forest Reserve of Malaysia, it was concluded that the distribution and abundance of *Koompassia sp*. was highly correlated with chemical properties of soil where they absorbed more nitrogen, potassium, magnesium and zinc [6]. However, other soil properties like soil organic carbon content and decomposition rate have also change with elevation [7], which may also possibly affect forest composition and tree growth along mountain slopes. Such researches are also provide evidence that though one area get exact same climatic condition the species dominance varies significantly and it appears to be due to another factor of locality i.e. edaphic factors. In our study we have also seen dominant patches of some particular species in same climatic condition. So this research work have been done to explore those unseen factors.

Materials and Methods

The experimental area is located in moist forest of Balugaon Forest Range under Khordha Forest Division of Odisha. The geographic location is 19°67′ to 19°93′ North latitude and84°93′ to 85°27′ East longitude with an altitude varying from 30 to 200 m above mean sea level. Some dominating vegetation within this area were studied.

The experiment was laid out in a Randomized Block Design (RBD) with three replications. It was consisted of seven treatments comprising seven dominating tree species which are *Shorea robusta* (T_1), *Tectona grandis* (T_2), *Mallotus philippensis* (T_3), *Xantolis tomentosa* (T_4), *Acacia nilotica* (T_5), *Bambusa bambos* (dwarf) (T_6) and *Bambusa bambos* (T_7). These species are dominating in different locations naturally.

The study was carried out under seven dominating vegetation as mentioned above which are located under the same agro climatic condition in Balugaon forest range. For this a thorough survey was conducted and the locations where above species are dominating naturally were identified. For each species three locations were identified which are treated as three replications. A total of 21 locations were selected. In each location a sampling unit of 20m X 20m was laid out in representative point. The data on vegetation characters and soil characters were recorded from these sampling units following standard procedures. The physicochemical property of collected soil samples were analyzed in laboratory.

Results and Discussion

The observations were recorded on physico-chemical parameters of soil collected from different depths i.e.0-25cm (D_1), 25-50cm (D_2), 50-75cm (D_3) and 75-100cm (D_4) which included bulk density, particle density, pH, electrical conductivity, organic carbon, and tree growth parameters e.g. height, DBH and basal area. Salient findings of the investigation are summarized and discussed below:

Physical properties of soil

Bulk density

Bulk density of soil under different dominating tree species tabulated in Table. 1. The statistical analysis resulted significant variation irrespective of soil depth. *Acacia nilotica* (T_5) possessed significantly higher bulk density (1.42 g/cm^3) while *Mallotus philippensis* (T_3) possessed minimum bulk density (1.27g/cm^3) among the species studied. The bulk density also varied remarkably under different depths of soil (0-100 cm) irrespective of species. D_1 (0-25 cm) registered lowest bulk density (1.22 g/cm^3) while D_4 (75-100cm) registered highest bulk density (1.43 g/cm^3). *Acacia nilotica* at depth 75-100 cm (T_5D_4) resulted significantly higher bulk density (1.52g/cm^3) whereas *Bambusa bambos* at 0-25 cm (T_6D_1) resulted minimum bulk density (1.15g/cm^3).

Table 1: Soil bulk density under different dominating tree species

Dominating tree species \ Depth of soil	Bulk density (g/cm^3)				Mean
	0-25 cm (D_1)	25-50 cm (D_2)	50-75 cm (D_3)	75-100 cm (D_4)	
Shorea robusta : T_1	1.25	1.30	1.36	1.43	1.33
Tectona grandis : T_2	1.20	1.25	1.30	1.38	1.28
Mallotus philippensis : T_3	1.18	1.23	1.32	1.37	1.27
Xantolis tomentosa : T_4	1.21	1.28	1.36	1.47	1.33
Acacia nilotica : T_5	1.32	1.38	1.45	1.52	1.42
Bambusa bambos : T_6	1.15	1.25	1.33	1.43	1.29
Bambusa bambos (Dwarf): T_7	1.21	1.26	1.32	1.41	1.30
Mean	1.22	1.28	1.35	1.43	1.31
$SE_{(m)}$ of species = 0.02		$CD_{(0.05)}$ of species = 0.05			
$SE_{(m)}$ of soil depth = 0.01		$CD_{(0.05)}$ of soil depth = 0.04			
$SE_{(m)}$ of Species x Soil Depth = 0.03		$CD_{(0.05)}$ of Species x Soil Depth = 0.09			

The variation in bulk density under different tree species irrespective of depths may be due to difference in quality and quantity of leaf litter added in the soil over the years and parent material of soil under different species. The highest Bulk Density under *Acacia nilotica* may be correlated its potential to grow in heavy soil in comparison to others in the study. Irrespective of species, the bulk density increases with increase of soil depth. This may be due to more pressure on soil layer towards higher depth. In upper layers pressure is less because mass of soil is less and also accumulation of organic matter in upper layers which makes soil less compact. Bulk density increases with increase in soil depth because lower layer were more compact under weight of upper portion of soil and also due to lower amount of organic matter in deeper layer [8].

Particle density

Partiicle density of soil under different dominating tree species are tabulated in Table. 2. The result exhibited significant variation irrespective of soil depth. *Xantolis tomentosa* (T_4) possessed significantly higher particle density (2.61 g/cm^3) while *Bambusa bambos* (Dwarf) (T_7) possessed minimum particle density (2.44 g/cm^3) among all species studied. The particle density of soil in different depths irrespective of species did not reflect significant variation and ranged from 2.47 g/cm^3 in D_2 to 2.51 g/cm^3 in D_4. The particle density under the interaction of tree species and soil depth was also found non-significant variation. It varied from 2.37 g/cm^3 in *Shorea robusta* at 75-100 cm to 2.69 g/cm^3 in *Xantolis tomentosa* at 0-25 cm depth.

Table 2: Soil particle density under different dominating tree species

Dominating tree species \ Depth of soil	Particle density (g/cm^3) 0-25 cm (D_1)	25-50 cm (D_2)	50-75 cm (D_3)	75-100 cm (D_4)	Mean
Shorea robusta : T_1	2.48	2.53	2.43	2.37	2.45
Tectona grandis : T_2	2.43	2.44	2.46	2.49	2.46
Mallotus philippensis : T_3	2.40	2.45	2.53	2.52	2.47
Xantolis tomentosa : T_4	2.69	2.46	2.65	2.66	2.61
Acacia nilotica : T_5	2.54	2.55	2.50	2.62	2.55
Bambusa bambos : T_6	2.47	2.46	2.40	2.51	2.46
Bambusa bambos (Dwarf): T_7	2.48	2.41	2.48	2.41	2.44
Mean	2.50	2.47	2.49	2.51	2.49
$SE_{(m)}$ of species = 0.04	$CD_{(0.05)}$ of species = 0.11				
$SE_{(m)}$ of soil depth = -	$CD_{(0.05)}$ of soil depth = NS				
$SE_{(m)}$ of Species x Soil Depth = -	$CD_{(0.05)}$ of Species x Soil Depth = NS				

The variation of particle density under dominating tree species irrespective of depths may be ascribed to variation of soil particles in different locations where the species have been dominated. The soil under *Xantolis tomentosa* registered maximum may be due to its location in hill slopes containing less organic matter and more high density minerals. The lowest particle density under *Bambusa bambos* (Dwarf) may be due to presence of some low density minerals in soil.

Chemical properties of soil

Soil pH

Soil pH under different dominating tree species are recorded in Table 3. They indicated remarkable variation. *Acacia nilotica* (T_5) possessed significantly higher pH of 8.20 whereas soil under *Shorea robusta* (T_1) possessed minimum (5.89). The pH value varied significantly under different depths of soil irrespective of species. D_1 registered with lowest pH (6.38) whereas D_2 registered with highest pH (6.61). The interaction of dominating species with depth of soil resulted significant variation in pH of soil. *Acacia nilotica* at depth of 75-100 cm (T_5D_4) resulted highest pH (8.42) whereas *Mallotus philippensis* at depth of 75-100 cm (T_3D_4) resulted lowest pH value (5.68).

Table 3: Soil pH under different dominating tree species

Dominating tree species \ Depth of soil	pH 0-25 cm (D_1)	25-50 cm (D_2)	50-75 cm (D_3)	75-100 cm (D_4)	Mean
Shorea robusta : T_1	5.83	5.91	5.84	5.99	5.89
Tectona grandis : T_2	6.17	6.17	6.21	6.23	6.20
Mallotus philippensis : T_3	5.79	6.24	5.87	5.68	5.90
Xantolis tomentosa : T_4	6.22	6.88	5.91	5.82	6.21
Acacia nilotica : T_5	7.92	8.26	8.20	8.42	8.20
Bambusa bambos : T_6	6.08	6.13	6.26	6.20	6.17
Bambusa bambos (Dwarf): T_7	6.67	6.69	6.63	6.68	6.67
Mean	6.38	6.61	6.42	6.43	6.46
$SE_{(m)}$ of species = 0.13	$CD_{(0.05)}$ of species = 0.36				
$SE_{(m)}$ of soil depth = 0.01	$CD_{(0.05)}$ of soil depth = 0.22				
$SE_{(m)}$ of Species x Soil Depth = 0.25	$CD_{(0.05)}$ of Species x Soil Depth = 0.72				

The difference in pH value under different tree species may be ascribed to variation in organic acid produced from the decomposition of organic matter. The physical and chemical properties of organic matter produced from different tree species varies from one another. The quantity of organic matter produced, their decomposition and release of organic acid differ from species to species which influences soil pH. The high soil pH under *Acacia nilotica* (T_5) in comparison to other species may be due to its fast decomposition of leaf litter, low organic acid release from organic matter and less canopy cover of trees causing more evapotranspiration from soil. The lowest pH under *Shorea robusta* (T_1) and *Mallotus philippensis* (T_3) may be because of higher accumulation of leaf litter with slow rate of decomposition causing more organic acid released. The acidic condition of soil under *Shorea robusta* (T_1) has been reported in Royal Chitwan National Park (5.90-6.42)[9], in Koshi Tappu Wildlife Reserve (6.4-7.1)[10], and in *Shorea robusta* dominant central Himalaya forests (6.7-6.8)[11]. The variation in soil pH in different depths may be due to variation in base saturation and acid saturation in different layers. T_5D_4 resulted highest pH because of low organic acid release at higher depth of soil on the other hand significantly lower pH in T_1D_1 and T_3D_1 may be due to more acid saturation which happens because of slow decomposition of leaf litter of *Shorea robusta* (T_1) and *Mallotus philippensis* (T_3) which gets accumulated in large quantity in upper layer of soil. The findings in the Sal (*Shorea robusta*) forests of Goalpara district, Assam are in line with present result [12].

Soil electrical conductivity

Soil electrical conductivity under different dominating tree species, tabulated in Table 3, revealed significant variation. *Acacia nilotica* (T_5) witnessed significantly higher electrical conductivity (0.045 dSm^{-1}) while *Bambusa bambos* (Dwarf) (T_7) resulted soil of minimum electrical conductivity (0.005 dSm^{-1}).The electrical conductivity varied significantly under different depths of soil irrespective of species. It ranged from 0.019 dSm^{-1}in D_3 to 0.032 dSm^{-1} in D_1. The interaction of dominating species with soil depth resulted significant variation. *Acacia nilotica* at depth of 0-25 cm (T_5D_1) resulted higher EC (0.070 dSm^{-1}) whereas *Bambusa bambos* (Dwarf) at depth of 25-50 cm, 50-75 cm and 75-100 cm (T_7D_2, T_7D_3 and T_7D_4) resulted minimum EC (0.005 dSm^{-1}).

Table 4: Soil electrical conductivity under different dominating tree species

Dominating tree species \ Depth of soil	EC (dSm^{-1})				Mean
	0-25 cm (D_1)	25-50 cm (D_2)	50-75 cm (D_3)	75-100 cm (D_4)	
Shorea robusta : T_1	0.033	0.023	0.023	0.027	0.027
Tectona grandis : T_2	0.047	0.027	0.030	0.027	0.033
Mallotus philippensis : T_3	0.027	0.023	0.020	0.023	0.023
Xantolis tomentosa : T_4	0.033	0.020	0.030	0.023	0.027
Acacia nilotica : T_5	0.070	0.058	0.023	0.030	0.045
Bambusa bambos : T_6	0.007	0.005	0.005	0.005	0.006
Bambusa bambos (Dwarf): T_7	0.006	0.005	0.005	0.005	0.005
Mean	0.032	0.023	0.019	0.020	0.023
$SE_{(m)}$ of species = 0.006	$CD_{(0.05)}$ of species = 0.017				
$SE_{(m)}$ of soil depth = 0.004	$CD_{(0.05)}$ of soil depth = 0.013				
$SE_{(m)}$ of Species x Soil Depth = 0.012	$CD_{(0.05)}$ of Species x Soil Depth = 0.034				

The variation in electrical conductivity at soil under different dominating vegetations may be correlative with variation in soil texture, soil pH and soluble salt in the soil. The highest EC under *Acacia nilotica* (T_5) may be due to its clayey soil, higher pH and presence of more soluble salt in the soil. Lower value under two genotypes of bamboo may be because of loamy sand – clay loam soil and relatively low pH. The variation of EC in different depths due to difference in soil pH and concentration of soluble salts. Similar results in EC under *Bambusa bambos* (T_5) reported in mid hills of Himachal Pradesh [13].

Soil organic carbon

Soil organic carbon under different dominating tree species, recorded in Table 5, reflected a significant variation. *Bambusa bambos* (T_6) claimed significantly higher soil organic carbon (13.85 g/kg soil) while *Shorea robusta* (T_1) secured minimum organic carbon (5.44 g/kg soil). The organic carbon also varied significantly with soil depth irrespective of the species. D_1 registered highest soil organic carbon i.e. 10.09 g/kg of soil while D_4 registered with lowest organic carbon 6.21 g/kg of soil. The interaction of dominating species with depth of soil also resulted significant variation among different combinations. *Bambusa bambos* at depth of 0-25 cm (T_6D_1) resulted relatively higher soil organic carbon (17.81 g/kg of soil) whereas *Shorea robusta* at depth of 75-100 cm (T_1D_4) recorded minimum (3.44 g/kg of soil).

Table 5: Soil organic carbon under different dominating tree species

Dominating tree species \ Depth of soil	Organic carbon (g/kg soil)				Mean
	0-25 cm (D_1)	25-50 cm (D_2)	50-75 cm (D_3)	75-100 cm (D_4)	
Shorea robusta : T_1	07.64	05.22	05.48	03.44	05.44
Tectona grandis : T_2	12.54	07.83	07.38	05.66	08.35
Mallotus philippensis : T_3	07.16	05.33	03.93	06.27	05.67
Xantolis tomentosa : T_4	09.78	04.82	04.95	03.93	05.87
Acacia nilotica : T_5	07.97	06.03	04.75	04.56	05.83
Bambusa bambos : T_6	17.18	13.51	12.35	12.37	13.85
Bambusa bambos (Dwarf): T_7	08.36	07.54	07.39	07.22	07.63
Mean	10.09	07.18	06.60	06.21	07.52
$SE_{(m)}$ of species = 0.96	$CD_{(0.05)}$ of species = 2.73				
$SE_{(m)}$ of soil depth = 0.72	$CD_{(0.05)}$ of soil depth = 2.07				
$SE_{(m)}$ of Species x Soil Depth = 1.92	$CD_{(0.05)}$ of Species x Soil Depth = 5.45				

Difference in soil organic carbon under different dominating tree species may be due to variation in production of organic matter and their decomposition under different tree species. Many authors reported variation in organic carbon with change in vegetation. Amount of organic carbon was 1.5-2.0 times greater in the pure teak forest than in adjoining mixed forests in Madhya Pradesh [14]. Maximum organic carbon under *Bambusa bambos* perhaps due to its very fast growth rate and addition of large quantity of leaves and dead roots under soil in comparison to its counterparts. On the other hand, lowest organic carbon content under *Shorea robusta* may be attributed to low decomposition and low production of organic matter of this species as it is a slow growing species among the species studied. The decrease of organic carbon with increasing depth of soil may be due to higher accumulation of organic matter on top layer of soil after falling of litter from tree. The gradual decrease in organic matter with respect to depth was also observed in many researches [15] [16] [17]. Variation of organic carbon under different combination of species and soil depths may be ascribed to variation of organic carbon under different species and different soil depth.

Growth performance of some dominating vegetations

Growth performance of selected dominating vegetations are recorded and tabulated in Table no.6 given below.

Height

The average height of height of trees ($\geq$ 10 cm gbh) were found significantly different under different species. *Tectona grandis* excelled in height growth registering 37.35m whereas *Bambusa bambos* (Dwarf) achieved minimum height (3.95 m). The order of plant height in different dominating species was *Tectona grandis* > *Shorea robusta* > *Bambusa bambos* > *Mallotus philippensis* > *Xantolis tomentosa* > *Acacia nilotica*

> *Bambusa bambos* (Dwarf). However, a parity in height growth was observed in T_1 and T_2, T_3, T_4 and T_6.
The variation in height growth of different species in the same agro-climatic zone, may be due to the variation in apical growth of different genotypes and site condition. *Tectona grandis* and *Shorea robusta* are genetically superior in terms of apical dominance over their counterparts. *Bambusa bambos* (Dwarf) although dominates in large patch in hill slopes which shows its dominance in poor site condition but has low apical dominance. The result found in the study was found similar to findings of different researchers. Heights of 35 m in 46 year-old teak have been reported in Madhya Pradesh, India [18]. Similarly, in Southern India the greatest height of a teak tree in 60 years growth were 58 m [19]. Similarly during studying spatial yield model for *Shorea robusta* in Nepal it is reported that sal tree growing in favorable conditions can reach up to 45 m in height, which has also been verified in field measurements [20]. Height of plants are also considered as one of the indices for judging site quality. From this investigation it may be assumed that the site where the species has reached significantly higher height may be of better site quality than the site where plant have attained significantly lower height. Maximum culm height was recorded in *Bambusa bambos* (17.56 m) at Singalkhanch, Ukai, Tapi, Gujarat [21].

Table 6: Growth of different dominating tree species (≥ 10 cm gbh)

Dominating tree species	Height (m)	DBH (cm)	Basal area (m^2/ha)
Shorea robusta : T_1	35.73	42.70	39.87
Tectona grandis : T_2	37.35	54.29	47.53
Mallotus philippensis: T_3	17.26	16.17	4.15
Xantolis tomentosa : T_4	16.58	12.61	2.27
Acacia nilotica : T_5	10.74	22.32	9.24
Bambusa bambos : T_6	18.59	108.00	84.41
Bambusa bambos (Dwarf): T_7	03.95	82.00	76.17

Diameter at Breast Height (DBH)
The average dbh of different dominating tree species differed significantly from one another. The clump diameter of *Bambusa bambos* was significantly higher (108 cm) over others. The lowest value (12.61 cm) was recorded under *Xantolis tomentosa*. The order of dbh in different dominating species was *Bambusa bambos* > *Bambusa bambos* (Dwarf) > *Tectona grandis* > *Shorea robusta* > *Acacia nilotica* > *Mallotus philippensis* > *Xantolis tomentosa.*
The variation in dbh may be due to genetic characters of species, plant density and site quality. The highest value under *Bambusa bambos* may be because of its genetic characters of congregation of many culms in a clump and production of a good number of culms every year. *Bambusa bambos* is also the fastest growing plant among the seven genotypes studied. Other than two bamboo genotypes significantly more lateral growth has been found under *Tectona grandis* followed by *Shorea robusta* because genetically those are superior trees attaining large size over others. In support of their height they have proportionately attained larger lateral growth to maintain their form and existence. Diameters of 70 cm in 46 year-old teak have been reported in Madhya Pradesh, India [18]. Similarly, in Southern India teak tree in 40 years attained largest diameter growth of 75 cm [19].

Basal area
The basal area per hectare of dominating species differed significantly. *Bambusa bambos* generated highest basal area while *Xantolis tomentosa* registered lowest. The order of basal area per hectare in different dominating species was *Bambusa bambos* > *Bambusa bambos* (Dwarf) > *Tectona grandis* > *Shorea robusta* > *Acacia nilotica* > *Mallotus philippensis* > *Xantolis tomentosa.*
The variation in basal area of different genotypes per unit area may be ascribed to difference in their diameter growth and plant density. *Bambusa bambos* recorded maximum basal area because of its highest dbh and appreciable plant density. A study in alluvial plain Kamrup Sal Forest of Assam resulted that basal area of the *Shorea robusta* was of 26.08 m^2ha^{-1} [22]. Among the total basal area of sal, 30-45 cm girth class consist of highest basal area i.e. 10.44 m^2ha^{-1} and it was followed by 45-60 cm girth class with 6.63 m^2ha^{-1} and 15-30 cm girth class with 3.98 m^2ha^{-1}. Basal area between 7-29 m^2 ha^{-1} from Sal forest found in Central India [23]. Basal area (BA) of 17.85 m^2/ha and 14.13 m^2/ha assessed by in community and private plantations in seven Tarai districts of Nepal [24].

Conclusion
The present study on "Analysis of soil physico-chemical properties and growth parameters under some dominating vegetations" revealed a significant relationship between the seven dominating tree species such as *Shorea robusta, Tectona grandis, Mallotus philippensis, Xantolis tomentosa, Acacia nilotica, Bambusa bambos* and *Bambusa bambos* (Dwarf) with their soil condition. Different species exhibited distinct soil characteristics with regard to bulk density, particle density, pH, electrical conductivity, organic carbon within the same climatic condition. These species formed almost pure patches in the sites tested exhibiting that these are the suitable species for such sites although their growth and density varied from one another. The results provided a clear indication that within the same climatic condition, the productivity of different tree species could be remarkably different because of variation in edaphic condition in different locations. Hence, it may be concluded that for a selected site the edaphic factors should be taken into account for selection of suitable species, for successful establishment of a plantation and for getting maximum productivity.

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