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Geo-Information based Soil Fertility Status of Deogarh District of Odisha, India

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A B S T R A C T

The present investigation has been designed to analyse the Geo-information based soil fertility status and to prepare GPS-GIS based soil fertility maps with respect to soil pH, organic carbon, available N, P and K for soils of Deogarh district located in North-Western Plateau Agroclimatic Zone of Odisha, India. Results revealed that, soil pH varied from 3.8 to 8.3 with a mean value of 5.5; that of soil organic carbon from 0.2 to 18.0 g kg^{-1} with a mean value of 6.6g kg^{-1}. Soils are safe for all types of crop production with respect to the soluble salt content. Soil available N content varied from 87.5 to 237.5 kg ha^{-1} with a mean value of 123.5 kg ha^{-1}; that of available P content from 4.0 to 65.3 kg ha^{-1} with a mean value of 13.8 kg ha^{-1} and that of available K from 37.0 to 787.0 kg ha^{-1} with a mean value of 288.4 kg ha^{-1}.

Introduction

Soil test based fertility management is an effective tool for of agricultural soils that have high degree of spatial variability which find out the soil fertility related production constraints of the study area and suggest the remedial measures for optimum production of the crops (Rawal *et al.,* 2018). Global Positioning Systems and Geographic Information Systems (GPS-GIS) can be efficiently use for monitoring soil fertility status (Thombare *et al.,* 2017). Fertilizer use can be better optimised by utilizing knowledge of 'soil fertility maps' prepared with the help of Geographical Information System (GIS) (Dash *et al.,* 2018). GPS based soil fertility evaluation also helps in monitoring the soil health from time to time (Swain *et al.,* 2019). Taking these concepts into cognizance, an attempt has been made to analyse soil fertility status with respect to basic soil physico-

chemical properties and primary macronutrients of an agriculturally important district of Odisha namely Deogarh (earlier Debagarh). Total 358 numbers of GPS based soil samples were analysed and GPS-GIS based soil fertility maps were prepared for key soil properties, which can be highly beneficial in guiding the farmers, manufactures and planners.

Materials and Methods

Deogarh district has a geographical area of 2781.66km^2 with gross cropped area and cropping intensity of 1,08,000 ha and 189% respectively. The District is in between longitude 84° 28' - 85° 15' East and latitude 21° 11'- 21° 43' North with a mean altitude of 630 feet above Mean Sea Level (MSL) in the North-Western Plateau Zone Agroclimatic Zone of Odisha. The district shares borders with Sambalpur, Sundargarh and Angul districts. It constitutes 3 development blocks namely Barkote, Reamal and Tileibani. All the three Blocks of the district namely Tileibani, Reamal and Barkote mostly drain to the river Brahmani, which is the most important river flowing through this district (Mishra, 1988). The lands of the district have very high degree of slope. The elevation gradually decreases on the south eastern part on either side of the river Brahmani. The agricultural land of the district can be marked to have five landforms such as hill, ridges, valley, levee and stream terrace which can be further divided into different land types and sub land types with distinct physiographic units (Mishra, 1985). The climate of this region is hot, moist, sub humid with dry summer & mild winter. Mean annual rainfall is 1582 mm. The mean maximum and mean minimum temperature is 38°C and 18°C respectively.

Total 358 numbers of GPS based composite soil samples from different blocks of Deogarh District namely Barkote (102), Reamal (137) and Tileibani (119) were collected using GPS instrument (Garmin make; model: 76MAPCSx). Soils were analysed for pH (1:2) (Jackson, 1973), EC(1:2) (Jackson, 1973), organic carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), phosphorus (Bray and Kurtz, 1945) and potassium (Hanway and Heidel, 1952). Base map of the study area was geo-referenced and digitized. Latitude, Longitude and soil analysis data were entered into attributed table and linked to Arc GIS software for making thematic soil fertility maps.

Results and Discussion

Soil reaction

Soil pH of Deogarh district was found to be varying from 3.8 to 8.3 with a mean value of 5.5. In Barkote block, soil reaction or pH varied from 3.9 to 6.6; that of Reamal block from 4.0 to 8.3 and that of Tileibani block from 3.8 to 6.7. The mean value of soil pH in Barkote, Reamal and Tileibani blocks were observed to be 5.4, 5.9 and 5.4 respectively (Table 1). GPS and GIS based map for soil pH of Deogarh district has been presented in Figure 1. Soils of Deogarh district were detected to be extremely acidic (10.3%), very strongly acidic (15.4%), strongly acidic (26.3%), moderately acidic (27.7%), slightly acidic (11.7%) and neutral to alkaline (8.7%). Most of soils of the study area (92.7%) were identified to be suffering from different levels of soil acidity. Hence, soil acidity is the most challenging soil related crop production constraint of the area.

Electrical conductivity

Soil EC of Deogarh district was found to be varying from 0.001 to 0.93dSm^{-1} with a mean value of 0.1dSm^{-1}. In Barkote block, EC varied from 0.001 to 0.68dSm^{-1}; that of Reamal block from 0.001 to 0.51dSm^{-1} and

that of Tileibani block from 0.005 to 0.93 dSm^{-1}. The mean value of soil pH in Barkote, Reamal and Tileibani blocks were observed to be 0.2, 0.1 and 0.2dSm^{-1} respectively. Electrical Conductivity (1:2) of surface soil samples of the entire study area was found to be less than 2dSm^{-1} (Table 1). Hence, soils of the study area are safe for all types of crop production with respect to the soluble salt content.

Organic carbon

Soil OC of Deogarh district was found to be varying from 0.2 to 18.0 g kg^{-1} with a mean value of 6.6g kg^{-1}. In Barkote block, OC content varied from 0.7 to 16.8 g kg^{-1}; that of Reamal block from 0.2 to 17.0 g kg^{-1} and that of Tileibani block from 0.3 to 18.0 g kg^{-1}. The mean value of OC in Barkote, Reamal and Tileibani blocks were observed to be 7.0, 6.2 and 6.9 g kg^{-1} respectively (Table 1). GPS and GIS based map for soil OC of Deogarh district has been presented in Figure 2. Soil organic carbon status of major parts of Deogarh district were detected to be medium (50.0%) and low (34.9%); whereas only 15.1% of soils were observed to be high in organic carbon status. High organic carbon status not only promote microbial activity of the soil, but also helps in providing different nutrient elements in their plant available forms in to the soil solution (Singh *et al.,* 2018). Hence, enriching the soils with organic carbon by addition of organic matter to the soil will help in optimising crop productivity and sustaining soil health.

Available nitrogen

Soil available N content of Deogarh district was found to be varying from 87.5 to 237.5 kg ha^{-1} with a mean value of 123.5 kg ha^{-1}. In Barkote block, available N content varied from 87.5 to 162.5 kg ha^{-1}; that of Reamal block from 87.5 to 175.0 kg ha^{-1} and that of Tileibani block from 87.5 to 237.5 kg ha^{-1}. The mean value of available N content in Barkote, Reamal and Tileibani blocks were observed to be 121.6, 125.1 and 123.3 kg ha^{-1} respectively (Table 2). GPS and GIS based soil fertility map for available N of Deogarh district has been presented in Figure 3. The soils of entire district was found to be low (100%) with respect to available N content. Low N content can be attributed to prevailing soil acidity condition (Palwe and Yelwe, 2018).

Available phosphorus

Soil available P content of Deogarh district was found to be varying from 4.0 to 65.3 kg ha^{-1} with a mean value of 13.8 kg ha^{-1}. In Barkote block, available P content varied from 4.0 to 65.3 kg ha^{-1}; that of Reamal block from 5.0 to 64.3 kg ha^{-1} and that of Tileibani block from 6.6 to 54.3 kg ha^{-1}. The mean value of available P content in Barkote, Reamal and Tileibani blocks were observed to be 13.8, 13.7 and 14.2 kg ha^{-1} respectively (Table 2).

GPS and GIS based soil fertility map for available P of Deogarh district has been presented in Figure 4. The available P status of major portion of soils of Deogarh district was found to be low (54.7%) and medium (43.3%); whereas only 2% of soils were identified to be high with respect to available P status. Available P content is greatly dependent on organic carbon status and microbial activity of the soils. The low to medium status of available P can be well correlated to existing organic carbon status. Such type of available phosphorus status was also noticed in the soils of Odisha during fertility mapping (Mishra *et al.,* 2014; Mishra *et al.,* 2017).

Table.1 Soil chemical properties of Deogarh District

Sl. No	Block Name	pH (1:2)		EC (dSm^{-1})		OC ($g\ kg^{-1}$)	
		Range	Mean	Range	Mean	Range	Mean
1	Barkote	3.9 - 6.6	5.4	0.001-0.68	0.1	0.7-16.8	7.0
2	Reamal	4.0-8.3	5.9	0.001-0.51	0.1	0.2-17.0	6.2
3	Tileibani	3.8-6.7	5.4	0.005- 0.93	0.1	0.3-18.0	6.9

Table.2 Soil available nutrient status of Deogarh District

Sl. No	Block Name	Available N ($kg\ ha^{-1}$)		Available P ($kg\ ha^{-1}$)		Available K ($kg\ ha^{-1}$)	
		Range	Mean	Range	Mean	Range	Mean
1	Barkote	87.5-162.5	121.6	4.0-65.3	13.8	37.0-787.0	297.6
2	Reamal	87.5-175.0	125.1	5.0-64.3	13.7	62.0-610.0	282.0
3	Tileibani	87.5-237.5	123.3	6.6-54.3	14.2	57.0-631.0	287.9

Fig.1 Soil pH map of Deogarh District

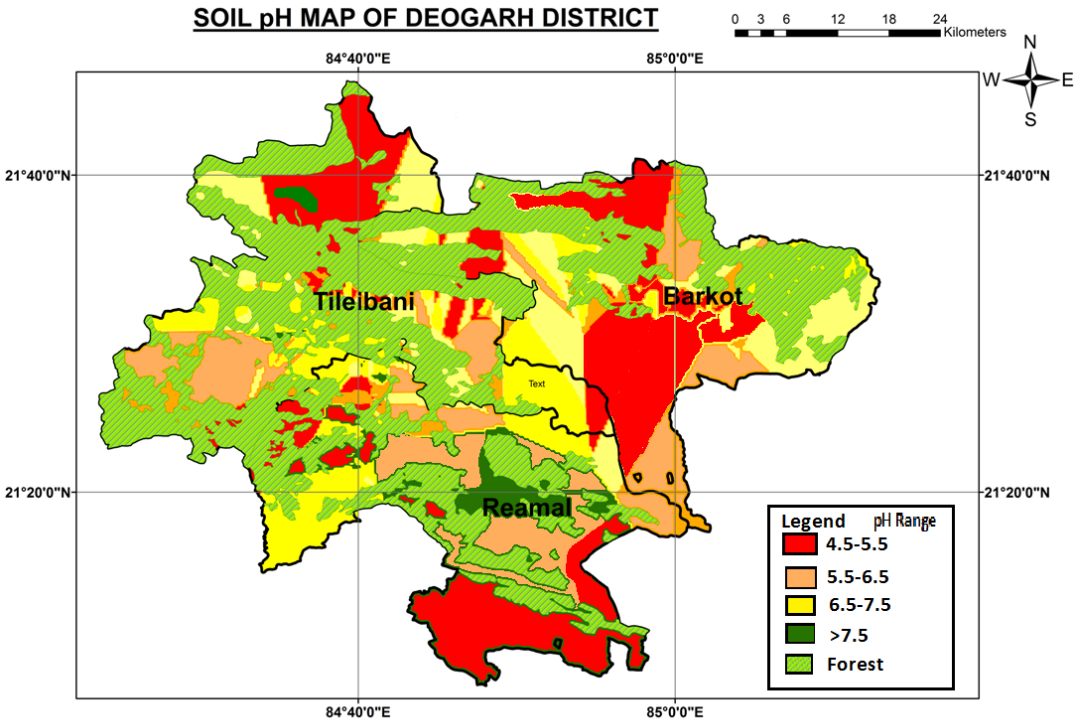


Fig.2 Soil organic carbon map of Deogarh District

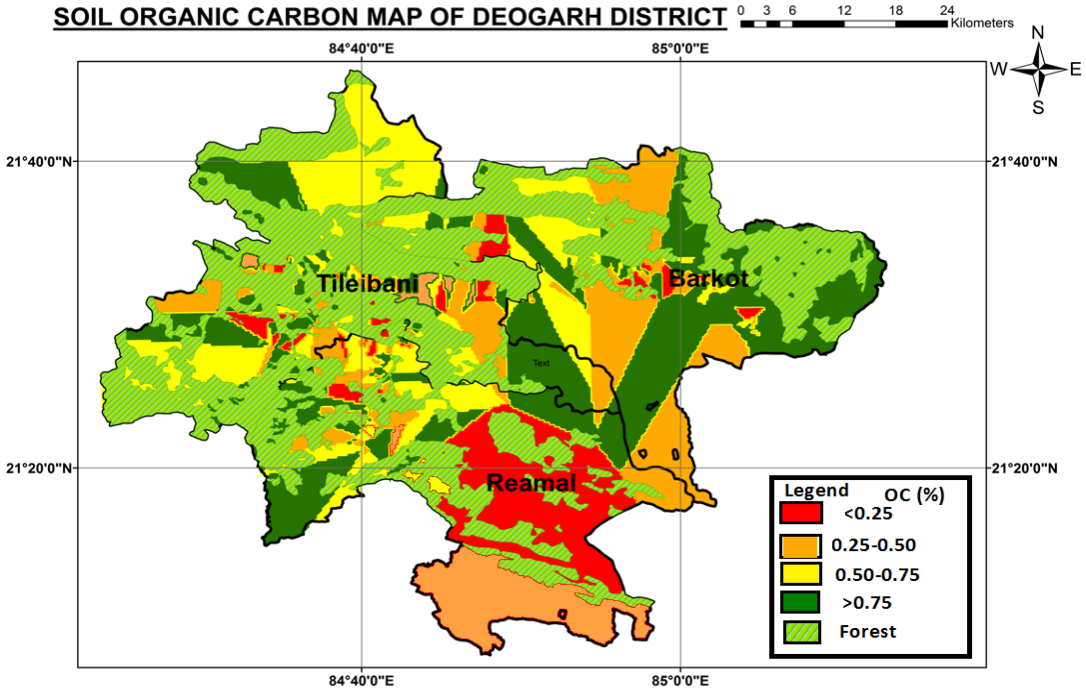


Fig.3 Available nitrogen map of Deogarh District

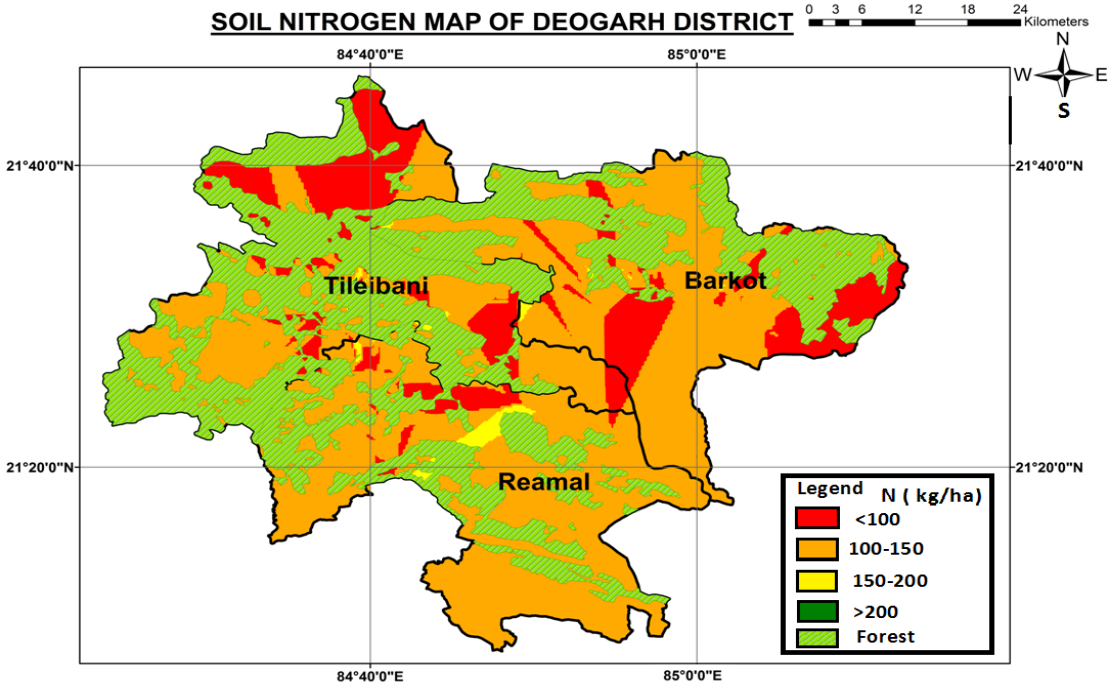


Fig.4 Available phosphorus map of Deogarh District

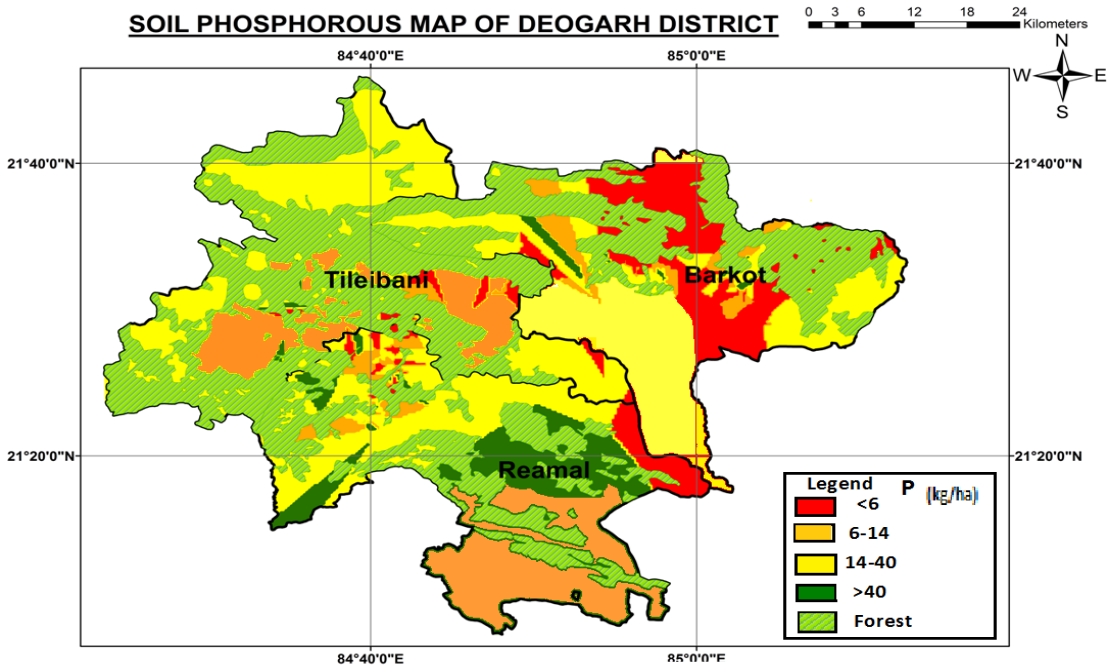
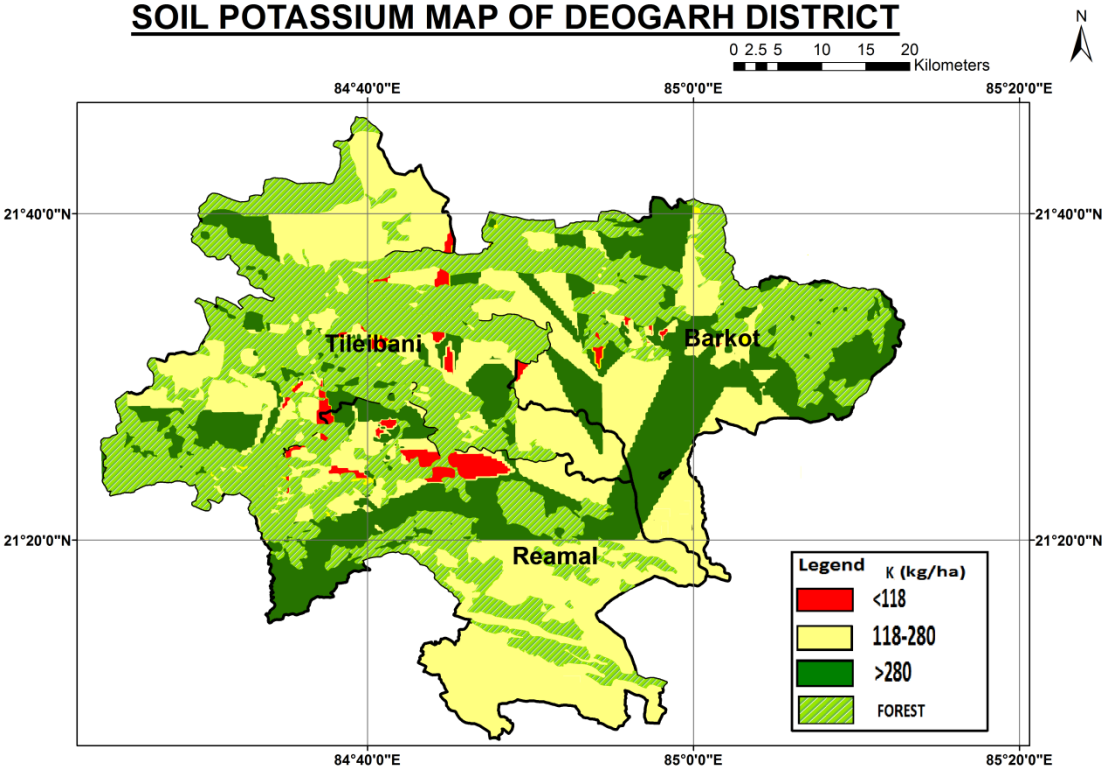


Fig.5 Available potassium map of Deogarh District



Available potassium

Soil available K content of Deogarh district was found to be varying from 37.0 to 787.0 kg ha^{-1} with a mean value of 288.4 kg ha^{-1}. In Barkote block, available K content varied from 37.0 to 787.0 kg ha^{-1}; that of Reamal block from 62.0 to 610.0 kg ha^{-1} and that of Tileibani block from 57.0 to 631.0 kg ha^{-1}. The mean value of available K content in Barkote, Reamal and Tileibani blocks were observed to be 297.6, 282.0 and 287.9 kg ha^{-1} respectively (Table 2). GPS and GIS based soil fertility map for available K of Deogarh district has been presented in Figure 5. The available K status of soils of Deogarh district was found to be medium (53.9%), high (41.9%) and low (4.2%). The medium and high K status can be attributed to K bearing parent materials of the district. Variation in available potassium across the soils was noticed by several workers (Chitdeshwari*et al.,* 2017; Mishra *et al.,* 2016; Mishra *et al.,* 2015).

Present study revealed that 92.7% of soils of Deogarh district are being affected by different levels of soil acidity. Soil acidity has not only many adverse effects on soil physical, chemical, biological properties but also it greatly hamper the availability of many nutrient elements to the plants. Hence, soil acidity is the most important soil related crop production constraint for the soils of Deogarh district. Suitable low cost liming materials must be applied to soils based on lime requirement. Addition of sufficient organic matter to the soils not only help in enhancing the organic carbon status of the soils but also enhance the microbial activity leading to increased release of plant nutrients into the soil solution. Hence, enriching the soils with organic carbon by addition of organic matter to the soil is highly recommended The EC of the soils was in safe range for all types of crop production. The soils of entire district were found to be low with respect to available N content, which is one of the most important challenges for higher crop production. Hence, application of nitrogenous fertilizers along with organic manures and soil ameliorant (lime) is of great importance to deal with soil acidity and low N availability. The available P status was mostly low to medium in range, which constituted 98% of the soil samples studied. Hence, application of soil test based phosphatic fertilizers along with organic manures and soil ameliorant (lime) is of great importance to increase P availability to crops. The available K status was mostly medium to high in range, which constituted 95.8% of the soil samples studied. Hence, application of only recommended doses of fertilizers in most parts of the district (having medium range of available K) will be sufficient to support optimum crop production. Even recommended doses of fertilizers can be reduced to 25%, where available K status is high. Since, most of the K fertilizers are imported and costly, a reduced application of K fertilizers will reduce the cost of cultivation. An integrated application of soil test based fertilizer doses, along with sufficient organic matter and suitable ameliorants can optimise crop productivity along with sustaining soil health.

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