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K Sivakumar
Assistant Professor (SS&AC), Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

M Nivas Raj
Research Scholar, Department of Remote Sensing and GIS, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

S Venkatesan
Senior Research Fellow, Department of Remote Sensing and GIS, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

P Gayathri
Senior Research Fellow, Department of Remote Sensing and GIS, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

S Pazhanivelan
Professor and Head, Department of Remote Sensing and GIS, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
K Sivakumar
Assistant Professor (SS&AC), Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Cadastral level Nutrient mapping of soil macronutrients of Madathukkulam block of Tiruppur district, Tamil Nadu

K Sivakumar, M Nivas Raj, S Venkatesan, P Gayathri and S Pazhanivelan

Abstract
An investigation was conducted in Madathukkulam block to determine the soil nutrient status and to generate cadastral level soil fertility maps. The total geographical area of the block is 14,994.11 ha and it lies between 10° 66' 12" and 10° 61' 77" N latitude and 77° 32' 17" and 77° 34' 12" E longitudes. The average rainfall of this region is 700 mm. Based on the soil analysis, fertility maps were generated at scale 1:5000 using ArcGIS. Based on the surface soil samples collected and analysed, the digital soil nutrient maps at village level were generated by geocoding the nutrient database by the survey points collected and by using geostatistical approach (Kriging). Madathukkulam block was found to have low nitrogen (< 280 kg ha^{-1}) and medium soil available phosphorus (11-22 kg ha^{-1}). The available K values were of high category (> 225 kg ha^{-1}). A plan for improving the fertility status of the area under agriculture in this block by way of suggesting different strategies can be developed for sustenance of agriculture, improving crop productivity and the profitability for the farmers in this region with the help of cadastral level nutrient mapping.

Keywords: Soil nutrient mapping, cadastral, geostatistical, kriging, soil fertility

Introduction

Soil test based nutrient application is an important concept centred on the principles of efficient and balanced fertilizer application and environmental safety. Mapping of soil nutrients facilitates the farmers and others who are related to work with soil nutrient management. Using advanced technologies of remote sensing it is possible to generate map of particular soil nutrient concerned. Soil nutrients are the predominant factor for achieving high, reliable and self-sustained food production (Chikowo *et al.*, 2014) [2]

Digitalization of soil nutrient mapping is done using the available technologies. Various models and predictions are done for generating map. Evaluation of soil nutrients using remote sensing and GIS methods used to suggest balanced fertilisers to increase crop productivity (Shruti *et al.*, 2017) [7].

A soil fertility map for a specific area will prove highly useful in guiding farmers and planners to decide the requirements of different fertilizers on a seasonal basis each year and to make predictions for increased requirements on the basis of crop pattern and intensity. Furthermore, NPK map can be used to apply fertilizer to an area, where there is low nutrient availability and also for efficient fertilizer management (Ismail and Junusi, 2009) [5].

Soil resource information in Tamil Nadu is available only at taluk level at 1:50,000 scale. This information is useful only for regional planning. But in recent days a village level database for a long time and effective implementation of all technologies and agricultural developmental programme at farm level is needed (Ali *et al.*, 2012) [1]. The micro level database at farm level can only help in identifying farm specific problems and potentials and to provide technologies and amelioration measures for increasing the agricultural production (Cichocinski, 1999) [3].

Materials and Method

The study area, Madathukkulam block consists of totally twelve panchayat villages *viz.*, Karathozhuvu, Kozhumam, Kumaralingam west, Metrathi, Myvadi, Pappankulam, Sangaramanallur North and South, Sholamadevi, Thanthoni, Thungavi and Vedapatty (Fig.1). The total geographical area of the block is 14,994.11 ha and it lies between 10° 61' 77" and 10° 66' 12"N latitude and 77° 32' 17" and 77° 34' 12" E longitude. The average rainfall of this region is 700 mm.

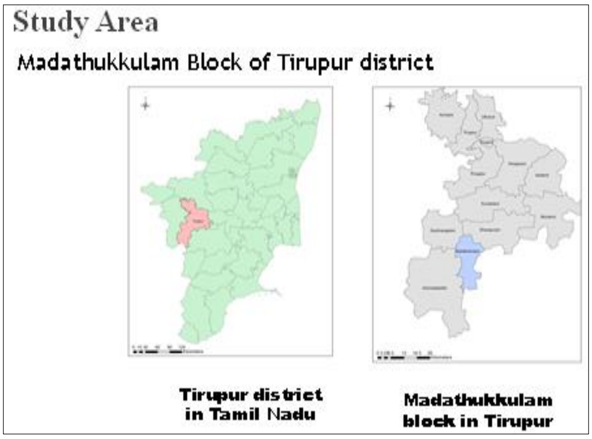

Fig 1: Study area of Madathukkulam block of Tiruppur district

Cadastral maps were collected for all the villages of Madathukulam block. The maps were georeferenced. The georeferenced maps were put under the process of digitization, edge matching, map stitching. Geocoding of the nutrient data base with the collected survey points were carried out. The thematic maps were created based on geostatistical analysis. The soil nutrient maps were generated finally. The methodology involved in the development of soil nutrient maps are explained below (Fig.2). Soil samples (120 Nos.) were collected from the villages of the study area and were analysed for soil available nitrogen (Subbiah and Asija, 1954) [10], phosphorus (Olsen, 1954) [6] and potassium (Stanford and English,1949) [9] following standard analytical procedures.

Methodology

a. Base Map Collection

The Scanned copy of village maps of Madathukulam block were collected from the Department of Survey and Land Records, The cadastral map of the village size used for the study was of the scale of 1:5000 (Large scale).

b. Digital Map Generation

The process of Map stitching, Georeferencing, Digitization, Edge Matching and Polyline to Polygon Conversion was carried out and the methodology followed is discussed here under.

1. Map stitching

Cadastral map of single village was scanned in two or more sheets which has to be stitched together as a complete cadastral map before Georeferencing and digitization.
Wise Image Pro 12.0 which has the powerful suite of tools for editing scanned drawings and maps was used to stich the scanned sheets. Adjacent sheets of cadastral maps were opened in the editing window of the software and image opacity was adjusted to view the overlapping areas of the sheets. Overlapping features, such as road intersections, buildings and water ways were identified and used as registration points. These registration points were used to align the adjacent sheets. Once the sheets pertaining to a village/cadastral map are aligned, the final image was exported from Wise Image software astiff file for further processing.

2. Georeferencing

Georeferencing is a process of assigning spatial coordinates of the data. Georeferencing was done by GIS software ArcGIS 10.6 using scanned copy of the cadastral map sheet that lacks spatial reference. The individual scanned copies of cadastral maps are added to a viewer with the help of Georeferencing tools and the X, Y coordinates of control points identified from GPS survey was entered. Minimum four control points are added to rectify and for error calculation. A link table consisting of control point information and their Root Mean Square Error (RMSE) value was used to optimize the control points. The control point having high error (higher RMSE) value was eliminated. The first order polynomial transformation was run to shift the cadastral map from its existing location to spatially correct location. To permanently transform the cadastral-map-raster-dataset to its actual location, rectify command was used. The resampling of raster data was performed by employing nearest neighbourhood algorithm as it is discrete data. The spatial reference of the rectified image was set to Geo Co-ordinate System (GCS) WGS_1984.

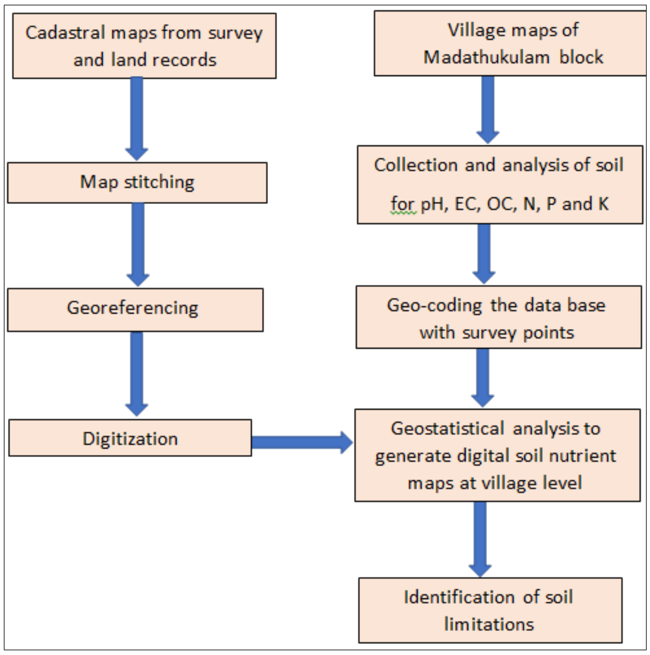

Fig 2: Flow chart showing the steps adopted to generate Cadastral level Nutrient maps of Madathukkulam block

3. Digitization

Using Arc Catalog 10.6 a new shape file was created to each village in the study area. The feature type was selected as polygon. The spatial references were imported from the base map i.e. rectified cadastral map sheets. In Arc Map both the shape file and the base map were opened. The new features were created by using the editor tool bar on the shape file by tracing the parcel boundaries of the cadastral map sheets. To avoid the errors and to maintain the topology Snapping tolerance was set as 5 pixels.

4. Edge matching

Edge matching is a method in which the edges of two adjacent villages were connected. The adjacent digitized sheets were opened and the edges of the parcel boundary are matched by identifying conjugate pairs. Conjugate pairs are having almost the same details that are present in two adjacent villages. The edges of the adjacent villages either overlap or result in a gap (sliver polygon).Using 'modify feature' option present in the editor toolbar, the edges were aligned spatially. If the difference is too large, a new central line will be drawn in between the edges of adjacent feature. Finally polyline of the villages were combined into a single shape file.

5. Polyline to polygon conversion

When the edges of the sheets were finalized and spatially aligned, the polyline feature were transformed into a polygon feature. Using that 'Polygon Feature' function, the polyline features are transformed to a polygon feature. To the main topology of the feature, the shape file has been imported as a feature class into a personal geodatabase. Topology rules have been applied and validated. The topology rules that were followed are given below ¬ Features must not overlap ¬ Features must not intersect The topological errors were rectified.

c. Generation of digital soil nutrient maps

The nutrient database was geo-coded with survey points. Geo-statistical Analysis was carried out to generate soil nutrient maps at village level using the ArcGIS 10.6(ArcMap) software.

d. Thematic map generation

The thematic maps were generated for macronutrients, of the soil in Madathukulam block at village level. The digitized data *viz*., cadastral map of 1:5000 scale formed the spatial data base. The attribute data base comprised the soil characteristics *viz.*, soil available nitrogen, phosphorus and potassium. Different thematic maps were prepared for major soil available nutrients *viz*., nitrogen, phosphorus and potassium of soil. The thematic maps prepared using GIS techniques facilitated in identifying potentialities and limitations of cultivated soil and also in developing management strategies for increasing crop production (Sivakumar *et al*., 2006) [8]

Results and Discussion

The soil samples (120 Nos.) were collected from twelve villages of Madathukulam block and were analysed for N, P and K. The mean values of the results of the samples analysed are presented in table 1.

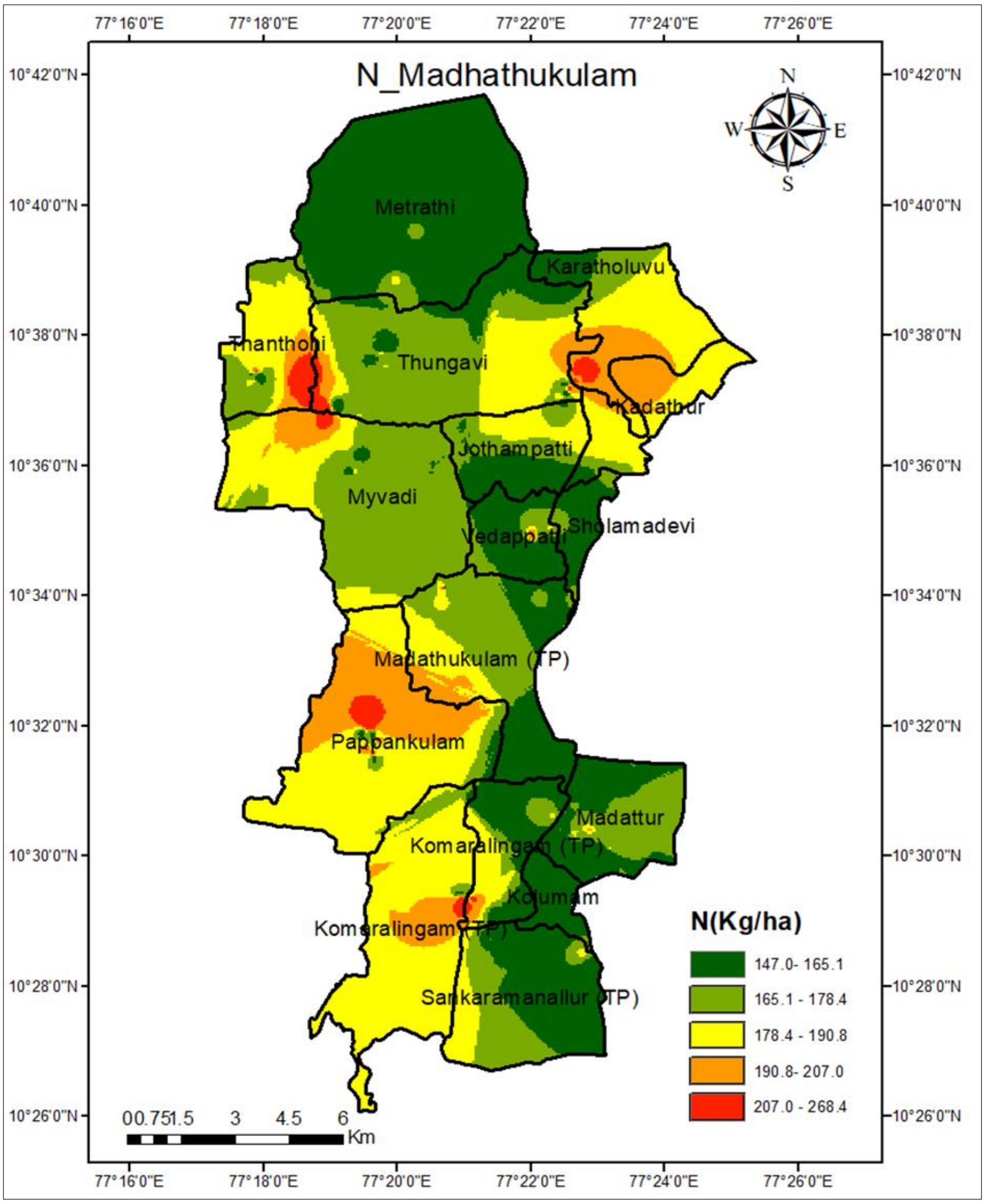

Fig 3: Cadastral level nutrient map of Madathukkulam block of soil available nitrogen

Table 1: Mean values of the Parameters of the soil collected from the villages of Madathukulam block

Sl. No.	Name of the Village	Mean values of soil Parameters		
		Avail-N (Kg/ha)	Avail-P (Kg/ha)	Avail-K (Kg/ha)
1.	Pappankulam	192.85	16.62	387.5
2.	Myvadi	192.15	15.44	347.5
3.	Kumaralingam	194.00	16.53	366.3
4.	Karatholuvu	190.75	18.46	410.0
5.	Thungavi	166.60	17.43	417.5
6.	Thanthoni	175.00	17.52	426.3
7.	Metrathi	156.10	16.34	406.3
8.	Sangaramanallur North	164.50	15.25	427.5
9.	Sangaramanallur South	163.80	16.99	390.0
10.	Sholamadevi	172.10	14.63	346.3
11.	Kozhumam	155.40	16.51	357.5
12.	Vedapatti	170.80	17.30	366.3

The available N content of the soil samples recorded lower values (i.e.) < 280 kg ha^{-1}. The values ranged from 155.40 (Kozhumam) to 194.00 kg ha^{-1} (Kumaralingam west). The available P values were recorded to be in the medium category (11 to 22 kg ha^{-1}).The mean values of the available P ranged from 14.63 (Sholamadevi) to 18.46 kg ha^{-1} (Karatholuvu). The available K values were of high category (> 225 kg ha^{-1}). The mean values of the available K ranged from 346.3 (Sholamadevi) to 427.5 kg ha^{-1} (Sangaramanallur North). The cadastral level soil nutrient maps for soil parameters *viz.*, available nitrogen, available phosphorus and available potassium (Fig.3 to 5) were generated at block level for Madathukkulam. Similar study was undertaken by Gayathri (2021)[4]. The limitations identified were low available nitrogen and medium availability of phosphorus.

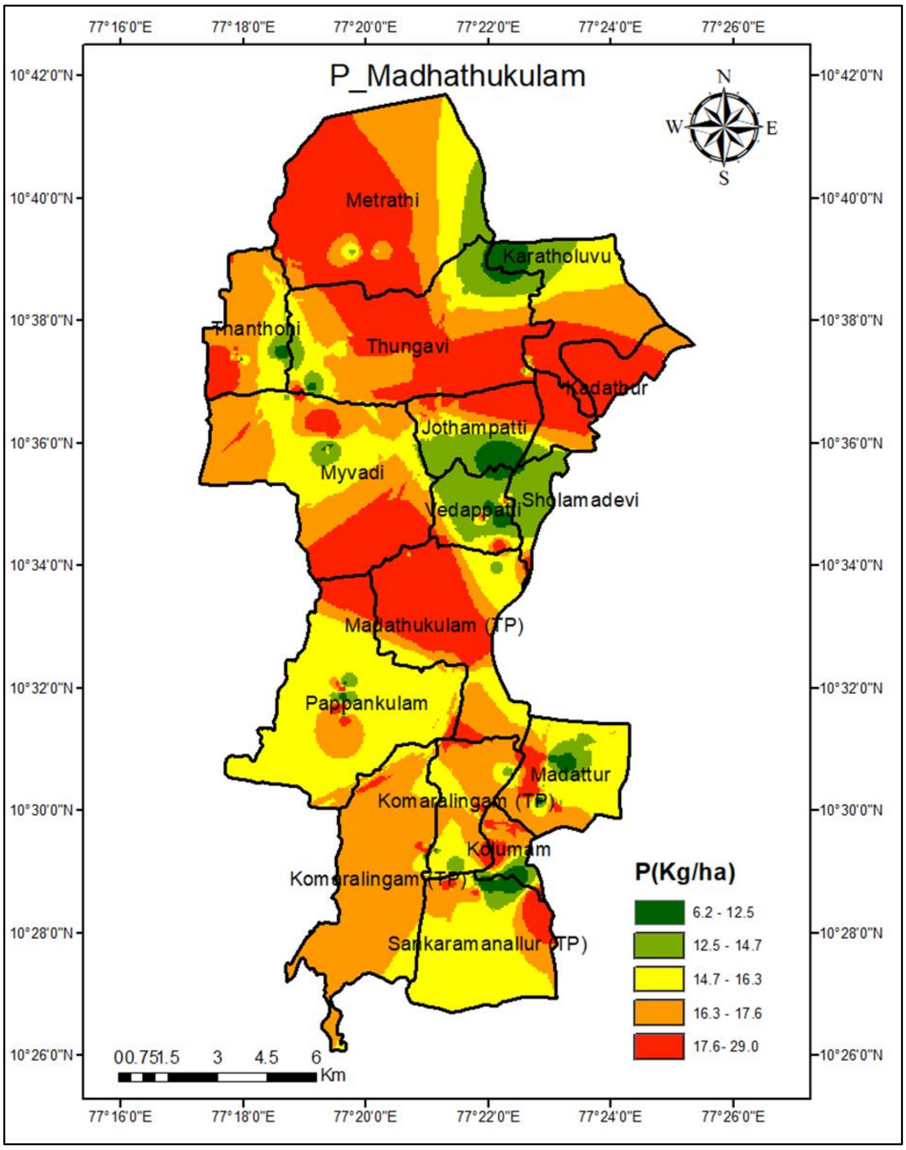

Fig 4: Cadastral level nutrient map of Madathukkulam block of soil available phosphorus

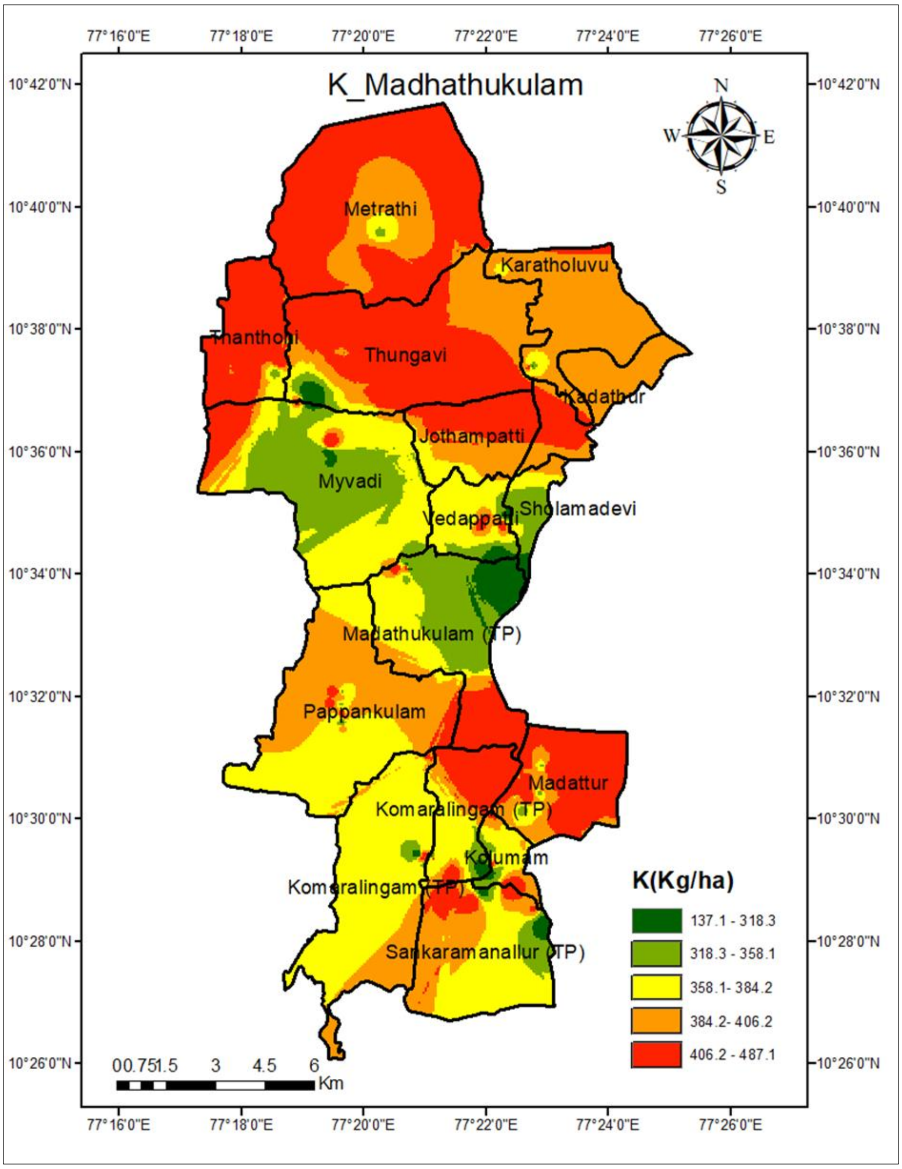

Fig 5: Cadastral level nutrient map of Madathukkulam block of soil available potassium

A plan for improving the area under agriculture in this block by way of suggesting different strategies can be developed for sustenance of agriculture, improving crop productivity and the profitability for the farmers in this region. The available nitrogen content can also be increased by supplementing the soil with nitrogenous fertilizers and biofertilizers. Green manure crops can also be raised in the soil and shall be ploughed in-situ.

Conclusion

The results of the study showed that the cadastral level nutrient mapping of Madathukkulam block was successfully generated using remote sensing and GIS tools. The available N content of the soil samples recorded lower values. The available P values were recorded to be in the medium category. The available K values were of high category.

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