Mapping of Available Sulphur in Soils of Nagapattinam District (Tamil Nadu) – A GIS Approach

Abstract:

The importance of Sulphur in agriculture is obvious because plants require Sulphur for synthesis of an essential amino acid, proteins, vitamins, coenzymes and activation of certain enzymes. Advanced techniques like global positioning system (GPS), geographic information systems (GIS) and precision agriculture facilitate soil secondary nutrient mapping which provides quantitative support for decision and policy making to improve agricultural approaches for balanced nutrition. Thus thematic maps are helpful in designing appropriate strategies to improve the productivity of crops. A study was carried out in the Nagapattinam district to assess Sulphur status and soil properties to create a data bank and to prepare thematic maps. Totally 1631 geo-referenced surface soil samples covering 11 blocks in Nagapattinam district were collected randomly at 0-15 cm depth and analyzed for various soil properties, such as pH, electrical conductivity (EC), organic carbon (OC), free $CaCO_3$. The overall soil reaction viewed in the Nagapattinam district at different blocks was mainly neutral with low soil salinity hazards. The data on organic carbon status in the soils was medium. The average free calcium carbonate status in the soils of different blocks revealed moderately calcareous. Average available sulphur was found to be in the range of 54.4 to 153 mg kg^{-1}. Higher availability of sulphur with combined average of 84.8 mg kg^{-1} was noticed in the soils of the entire district and could be attributed to high organic carbon content and heavy texture of the soils.

Keywords: *GIS, Mapping, Nagapattinam soil, Soil survey*

Introduction

Sulphur in agricultural soils occurs in organic and inorganic forms, with organic Sulphur accounting for more than 95 percent of the total Sulphur. Indian soils are showing depletion of sulphur, as deficiencies are emerging fast in several areas and caused decline in crop yields and total productivity. In the absence of sulphur plant shows deficiency symptoms and ultimately

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Is there any seasonal variation here? Did you collect all the samples in one season ot through out the year. Provide those information.

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results into disorders such as yellowing of leaves and chlorotic symptoms. In agriculture, global positioning system (GPS) and geographic information system (GIS) technologies have been adopted for better management of land and other resources for sustainable crop production (Arunkumar et. al., 2024; Palaniswami et al., 2011). Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection (Mahendra, 2010). GIS generated soil fertility maps may serve as a decision support tool for nutrient management (Iftikar et al. 2010). The importance of Sulphur in crop production point of view is well known, hence study was attempted to create data bank and thematic map for available sulphur in Nagapattinam district using GIS for suggesting suitable management strategies and site specific nutrient management. Geo-referenced surface soil samples covering 11 blocks in Nagapattinam district were collected randomly and analyzed for various soil properties to correlate with nutrient availability.

Materials and Methods

Study Area: Nagapattinam is the 4th largest district, lies on the east coast of Tamil Nadu, with a total geographical area of 2, 58,136 ha and lies between 100 16′ and 110 25′ degree north and 790 30′ and 800 01′ degrees east longitude (Fig.1). The district consists of 11 blocks viz. Vedaranyam, Nagapattinam, Keelaiyur, Talanayar, Kilvelur, Thirumarugal, Kuttalam, Kollidam, Mayiladuthurai, Sirkazhi, Sembanar Koil and 7 talukas. Soil is predominantly sandy in texture, and clayey in certain pockets, with slight salinity and alkalinity. The area lying between Nagapattinam and Vedaranyam is dominated by sand dunes and the soils under cultivation are mostly sandy in texture. Major area is covered under wealthy Cauvery delta zone and the rest is under coastal zone. The climate of the study area is semi-arid and receives a mean annual rainfall of 1337 mm. The mean annual air temperature is 31.17^0 C. The major crops grown in this region are Rice, Sugarcane, Coconut, Mango, Casurina, Brinjal and Cashew with vegetable crops such as brinjal, bhendi, chilli, cucumber, melons, gourds, and fruit crops like mango, cashew, guava, and sapota are also raised in lesser extent.

Soil Sampling: Geo-referenced surface soil samples collected randomly at 0-15 cm depth by adopting the standard procedures of soil sample collection. The GPS data (Latitude ºN and Longitude ºE) were collected from each sampling sites by using Garmin GPS 76CS model.

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Under the study area sub section, more details of the soil quality of that are based on secondary information shall be included.
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NAGAPATTINAM map shows a copyright symbol from other organization or institute. It looks like all the maps should be changed with proper legend, coordinate system, scale and labelling.

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Soil Analysis: The soil samples collected during the survey were processed after shade drying and passed through 2 mm sieve and analyzed for pH, electrical conductivity (EC), Organic carbon by Walkley and Black (1934) method, free $CaCO_3$ status by Piper (1966) method. The available sulphur content of the soil was estimated using 0.15% $CaCl_2$ extractant method (Williams and Steinbergs, 1959).

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Generation of map

The Nagapattinam district map (1:50,000) was vectorised using Raster to Vector software (R_2V), and then exported into Arc-GIS software. Database on soil available sulphur was developed using Microsoft Excel package. The database was exported to Arc GIS 9 software via dBase IV format and the attribute table was geocoded using mapping unit as the key field.

Results

Data on basic parameters like pH, EC, OC and free $CaCO_3$ are presented in Table 1. Range and mean values of soil available sulphur status in different blocks of Nagapattinam district is presented in Table 2. The pH ranged from 3.90 to 9.60 with a mean value of 6.63. The electrical conductivity (EC) of the soils varied from 0.079 to 2.59 dS m^{-1} with a mean value of 0.404 dS m^{-1}. Organic carbon content of soils ranged from 0.178 to 1.42 per cent with a mean value of 0.717 per cent. Almost all the soils were moderately calcareous in nature with values varied from 2.30 to 38.3 per cent and the mean value of 12.6 per cent.

The available sulphur ($CaCl_2$-S) content of the soils of Nagapattinam district ranged from 35.3 to 192 mg kg^{-1} with a mean value of 84.8 mg kg^{-1} indicating that the entire soils of the district was high in available sulphur (Table.2). The highest mean soil available sulphur content was noticed in Nagapattinam (153 mg kg^{-1}) and Keelaiyur blocks (118 mg kg^{-1}). The lowest S content was found in Mayiladuthurai block (49.2 mg kg^{-1}) followed by Vedaranyam (54.4 mg kg^{-1}) and Sirkazhi blocks (55.9 mg kg^{-1}). However almost all the blocks of Nagapattinam district revealed a sufficient sulphur status except soils of Mayiladuthurai block which exhibited a deficiency in sulphur (8.75 mg kg^{-1}). Thematic map was prepared for available Sulphur by considering the block means (Fig.2). The relationship between soil properties and sulphur was tested using the simple correlation tool (Das et. al. 2021).

Discussion

Soil reaction

The overall data on soil properties shows that, soil were neutral in reaction. In some blocks such as Thirumarugal, Kollidam and Vedaranyam, slightly acidic soil reaction was observed (< 4.00) which may be due to more leaching of bases by heavy rainfall during monsoon season at coastal regions (Mini et al., 2007). High alkaline soil reaction observed in the soils of Talanayar block (> 9.60) might be due to high CaCO3 content in the surface soils of these regions.

Electrical conductivity

Predominantly low soil salinity hazards (0.404 dS m^{-1}) were noticed in entire Nagapattinam district which may be due to the application of acidulating fertilizers in salt affected areas and more leaching of bases (Kumaraperumal, 2006). More than 90.0 per cent of the soils samples were found to have low salt concentration and few blocks viz. Nagapattinam (8.03 dS m^{-1}), Keelaiyur (6.29 dS m^{-1}) and Talanayar (6.12 dS m^{-1}) showed higher electrical conductivity which might be due to sea water intrusion in these coastal regions and similar observation was reported by Choudhary et al., (2008).

Organic carbon

The highest organic carbon content was evidenced in the soils of Kuttalam, Kollidam and Mayiladuthurai blocks which may be due to high organic matter addition through crop residues, green manures and their decomposition (Bayala et al., 2007). Further rice is the predominant crop grown in these blocks and hence the contribution from root biomass was also accounted for higher carbon status in the soils. Similarly low carbon status was observed in Vedaranyam, Nagapattinam and Thirumarugal blocks which might be attributed to erosion, leaching, rapid oxidation and decomposition of organic matter (Saha et al., 1996). Generally the organic matter content of coastal soils is relatively high compared to non-coastal soils under coastal humid climatic condition and such data are comparable to those of Bandyopadhyay et al., (1998) and Ghosh et al., (2007).

Free $CaCO_3$

The average free calcium carbonate status in the soils of different blocks revealed "Moderately calcareous. Higher free calcium carbonate content observed in Kuttalam, Sirkazhi and Kilvelur

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blocks may be due to more lime deposition in and around the clay particles or due to the process of calcification as outlined by Pandey et al., (2000).

$CaCl_2$-S

Higher availability of sulphur was noticed in the soils of entire district (Fig.2) and could be attributed to high organic carbon content and heavy texture of the soils in contrast to Entisol and Inceptisol where poor infiltration retarded the loss of sulphur through leaching (Borkotoki and Das, 2008). Lower sulphur availability was noticed in few blocks such as Mayiladuthurai, Vedaranyam and Sirkazhi. Among the three blocks, the soils of Mayiladuthurai block alone exhibited deficient S status could be ascribed to low organic carbon and coarse texture of the soils which are conducive for enhanced leaching by heavy rainfall (Takkar,1987).

Conclusion

From the present study it can be concluded that the chemical properties such as pH, EC, organic carbon and free $CaCO_3$ content of the soils was ideal for growing all the crops in this region and sufficient availability of Sulphur was noticed in all the blocks of Nagapattinam district. It also confirms that wide range of cereals, fruit crops, vegetable crops and plantation crops can be grown in this type of soil.

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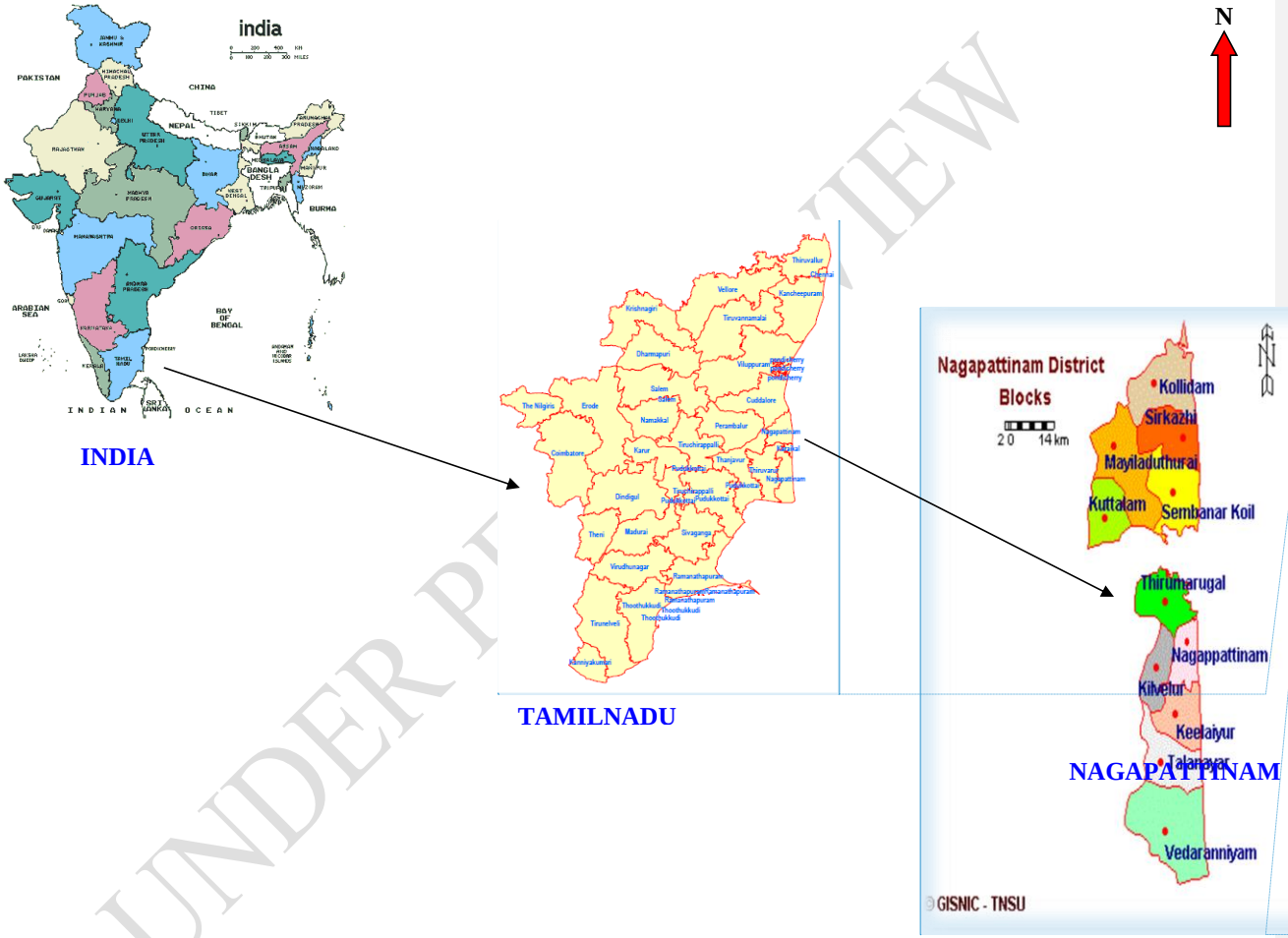

Fig.1 Location map of Nagapattinam district

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Table: 1. Range and mean values of soil properties in different blocks of Nagapattinam district

S. No.	Name of the block	Soil properties			
		pH	EC (dS m^{-1})	OC (per cent)	$CaCO_3$ (per cent)
1	Vedaranyam	4.30 - 8.90 (6.55)	0.060 - 2.50 (0.168)	0.120 - 0.990 (0.356)	1.00 - 26.0 (9.07)
2	Nagapattinam	5.70 - 7.90 (6.76)	0.080 - 8.03 (1.14)	0.097 - 1.14 (0.457)	3.00 - 39.0 (11.1)
3	Keelaiyur	4.70 - 8.40 (6.45)	0.110 - 6.29 (1.31)	0.150 - 1.29 (0.657)	5.00 - 24.0 (13.6)
4	Talanayar	4.50 - 9.60 (6.20)	0.060 - 6.12 (0.571)	0.120 - 1.89 (0.816)	2.30 - 44.0 (12.1)
5	Kilvelur	6.00 - 8.10 (7.13)	0.100 - 1.70 (0.293)	0.300 - 1.20 (0.729)	2.40 - 52.0 (18.3)
6	Thirumarugal	3.90 - 8.60 (6.18)	0.090 - 1.59 (0.263)	0.120 - 1.26 (0.568)	2.00 - 26.0 (11.1)
7	Kuttalam	5.36 - 8.51 (7.06)	0.070 - 0.800 (0.104)	0.150 - 1.80 (0.956)	2.00 - 65.0 (20.6)
8	Kollidam	4.00 - 7.51 (6.24)	0.060 - 0.220 (0.105)	0.300 - 1.56 (0.954)	2.00 - 27.0 (6.11)
9	Mayiladuthurai	5.64 - 8.27 (6.91)	0.070 - 0.190 (0.104)	0.120 - 1.47 (0.938)	1.60 - 13.4 (8.36)
10	Sirkazhi	5.40 - 7.80 (6.75)	0.070 - 0.560 (0.154)	0.300 - 1.53 (0.805)	2.00 - 85.0 (18.0)
11	Sembanar Koil	5.20 – 7.80 (6.65)	0.100 – 0.450 (0.228)	0.180 – 1.50 (0.654)	2.00 – 20.0 (10.3)
Overall Mean		**3.90-9.60 (6.63)**	**0.079-2.59 (0.404)**	**0.178-1.42 (0.717)**	**2.30-38.3 (12.61)**

( ) values in parentheses indicate the mean values

Table.2. Range and mean values of soil available Sulphur status in different blocks of Nagapattinam district

S. No.	Name of the block	**$CaCl_2$- S (mg kg^{-1})**
1	Vedaranyam	13.8 - 162 (54.4)
2	Nagapattinam	97.5 - 238 (153)
3	Keelaiyur	52.5 - 236 (118)
4	Talanayar	26.3 - 214 (79.4)
5	Kilvelur	17.5 - 238 (101)
6	Thirumarugal	38.8 - 234 (72.3)
7	Kuttalam	42.5 - 215 (90.6)
8	Kollidam	30.0 - 238 (81.2)
9	Mayiladuthurai	8.75 - 108 (49.2)
10	Sirkazhi	27.5 - 100 (55.9)
11	Sembanar Koil	33.8 - 139 (77.3)
Overall Mean		**35.3-192 (84.8)**

( ) values in parentheses indicate the mean values

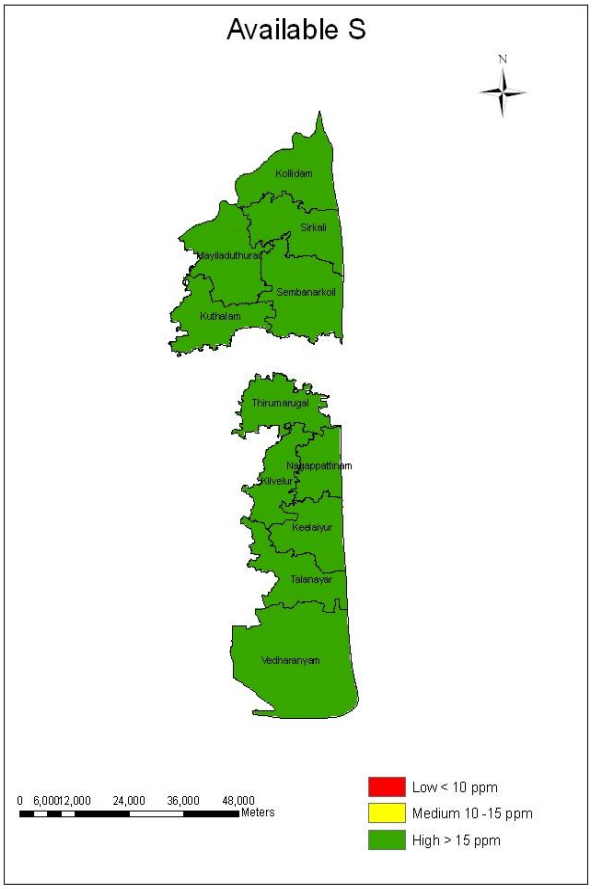

Fig.2. Thematic map of S

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