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B Rajeswari
MSc. (Ag.), Department of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

PVRM Reddy
Scientist, Soil Science, Regional Agricultural Research Station, Tirupati, Andhra Pradesh, India

KV Nagamadhuri
Principal Scientist, Soil Science, Regional Agricultural Research Station, Tirupati, Andhra Pradesh, India

Y Reddi Ramu
Associate Professor, Department of Agronomy, S. V. Agricultural College, Tirupati, Andhra Pradesh, India

Correspondence
B Rajeswari
MSc. (Ag.), Department of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

Soil fertility status of Nethakuppam watershed using RS and GIS

B Rajeswari, PVRM Reddy, KV Nagamadhuri and Y Reddi Ramu

Abstract
Two hundred fifty soil samples from Nethakuppam watershed in Ramachandrapuram mandal of Chittoor district of Andhra Pradesh were drawn at 10 ha interval and analysed for fertility parameters. Analytical data was interpreted. Statistical parameters like range, mean, standard deviation and coefficient of variation were calculated. Soil fertility maps were prepared for each parameter under GIS environment using Arc GIS 9.3.1. Soils were slightly acidic to strongly alkaline with non saline and soil organic carbon was low to medium. The available nitrogen (N) was low, available phosphorus (P) was ranged from medium to high and the available potassium was high and available sulphur was deficient to sufficient. Regarding available micro nutrients iron (Fe) and manganese (Mn) were deficient in about 3/4th of the watershed area whereas, available copper (Cu) and zinc (Zn) were sufficient in majority area of watershed soils. The fertility status in watershed revealed that, available N, S, Fe and manganese are important soil fertility constraints.

Keywords: Soil fertility status, grid method, Arc GIS 9.3.1, watershed, soil fertility constraints

Introduction
Soil is the vital natural resource for the survival of life on the earth and its assessment is the prerequisite for the determination of productivity of soil and the sustainability of the ecosystem. Therefore, assessment of nutrient constraints of soils being intensively cultivated with high yielding crops need to be carried out. Many reasons have been attributed for imbalance of nutrients in the soils such as increase demand from high yielding, intensive cropping, continued expansion of cropping onto marginal land with the low levels of micronutrients (Richard bell and Bernie dell, 2006) [13], increased use of chemically pure micronutrient free fertilizers, decreased recycling of crop residues and limited use of animal wastes (Setia and Sharma, 2004) [17]. In earlier days, conventional soil survey methods were used to obtain data on analysis of soil resources. Though the data obtained by such methods are reliable and accurate, it does not help in creating the layers of spatial variability of soil properties. In particular the evolution of Geographic Information System (GIS), Global Positioning System (GPS), Remote Sensing (RS) technologies has enabled the collection and analysis of data in all possible ways to create the accurate field maps and also assess complex spatial relationships between soil fertility factors (Reddy *et al*., 2014) [12]. Remote sensing technology has emerged as a powerful tool for studying soil resources as it helps in studying the soils in spatial domain in time and cost-effective manner (Saxena, 2003) [16]. Development of watersheds at micro-level is given a top priority by the administrators both at state and national level. Several management practices have to be taken up to improve the productivity in watershed area. Soil resource inventory plays a vital role to recommend suitable measures for the watershed development. Nethakuppam watershed in particular for soil resource management. Hence, the present investigation was planned and executed with the objective of identifying available nutrient constraints in soils of Nethakuppam watershed in Ramachandrapuram mandal of Chittoor district of Andhra Pradesh.

Materials and Methods
The watershed lies in between 13°.46' to 13º 54' North Latitudes and 79° 26' and 79° 38' E longitudes (Fig 1.). It has a total geographical area of 2,266 ha and comprises of three villages namely Nethakuppam, Anupalli and Chittathur kalepalli. (Fig 2.). The soils in the watershed were sandy clay loam to red soils. The climate of the watershed was semi-arid monsoon with distinct summer, winter and rainy seasons. The mean annual rainfall recorded for the last 10

years (2008 to 2018) was 636.6 mm of which 89 per cent was received during June to November. The mean annual temperature was 28.92ºC with mean summer temperature of 35.07ºC and mean winter temperature of 23.69°C. The maximum temperature recorded for the last ten years was 43.3ºC and the minimum temperature was 18.7ºC in the month of May and January, respectively. The natural vegetation of the watershed comprises of *Cynodon dactylon*, *Cyperus rotundus*, *Argemone maxicana*, *Lamea pinnatifiea*, *Blumea lacera*, *Chenopodium alba*, *Acacia nilotica*, *Borassus flabellifer*, *Tamarindus indica*, *Tephrosia purpurea*, *Parthenium hysterophorus*, *Azadirachta indica*, *Abutilon indica*, *Cyperus rotundus*, *Sygium cumini*, *Cassia auriculata*, *Cynodon dactylon and Calotropis giganteaetc*. Surface composite soil samples were collected using a handheld GPS on10 ha interval in the study area. A total of 250 samples were collected from the watershed. The soil samples were air-dried, ground (< 2 mm) and analyzed for physico-chemical and fertility parameters. The pH (1:2.5) and electrical conductivity (EC) (1:2.5) of soils were measured using standard procedures as described by Jackson (1973) [5]. Organic carbon (OC) was determined using the Walkley-Black method (Nelson and Sommers 1996) [8]. Available nitrogen (N) was estimated by alkaline permanganate method (Subbiah and Asija 1956) [19]. Available phosphorus (Olsen P) was measured using sodium bicarbonate (NaHCO3) as an extractant (Olsen and Sommers 1982) [9]. Available potassium (K) was determined using the ammonium acetate method (Jackson, 1973) [5]. Available sulphur (S) was measured using 0.15 percent calcium chloride (CaCl2.2H2O) as an extractant (Williams and Steinbergs, 1959) [20]. Micronutrients (Fe, Zn, Cu and Mn) were extracted by DTPA using the procedure outlined by Lindsay and Norvell (1978) [6]. Variability of data was assessed using mean standard deviation and coefficient of variation for each set of data. Availability of N, P and K in soils are interpreted as low, medium and high and that of available sulphur (S), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) interpreted as deficient and sufficient by following the criteria given in table 1. A dbf file consisting of data for X and Y coordinates in respect of sampling site location was created. A shape file (Vector data) showing the outline of Nethakuppam watershed area was created in ERDAS IMAGINE 9. The dbf file was opened in the project window and in X-field, longitudes "and in Y-field, "latitudes "were selected. The Z field was used for different nutrients. The Nethakuppam watershed file was also opened and from the "Surface menu "of Arc GIS geostatistical Analyst, "geo statistical wizard "option was selected. On the output "grid specification dialogue", output grid extend chosen was same as Nethakuppam watershed and the interpolation method employed was inverse distance weighted (idw).

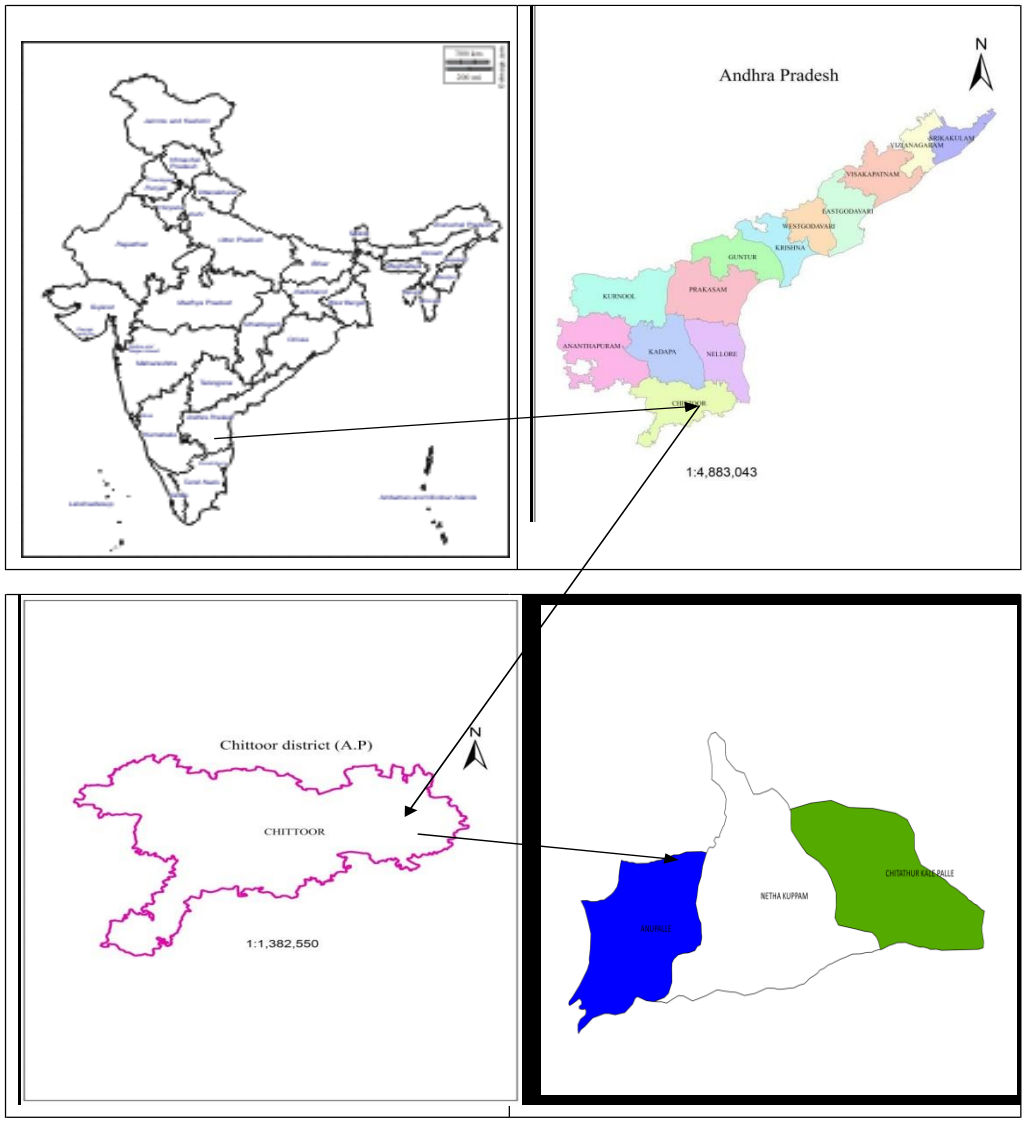

Fig 1: Location map of study area

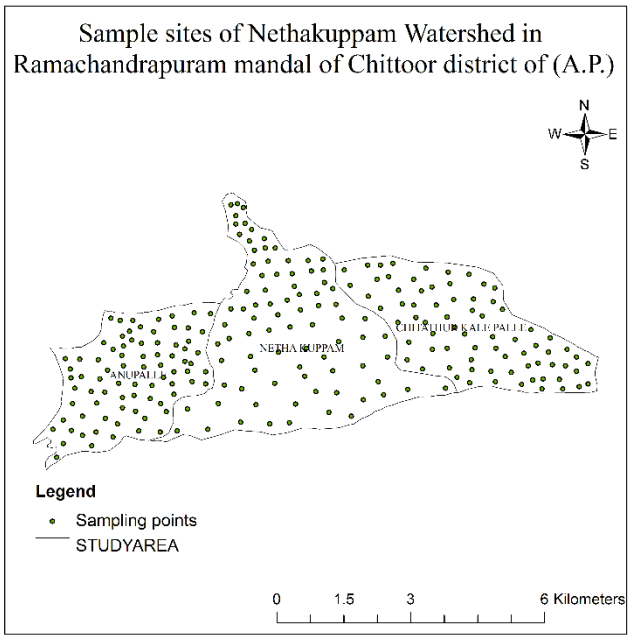

Fig 2: Sample site of Nethakuppam watershed

Table 1: Soil fertility ratings for available nutrients

Nutrients	Fertility rating major nutrients		
	Low	Medium	High
Organic carbon (%)	< 0.5	0.5 – 0.75	> 0.75
Macronutrients (kg ha-1)			
Available N	< 280	280 – 560	> 560
Available P2O5	< 22.9	22.9 – 56.33	> 56.33
Available K2O	< 129.6	129.6 – 336	> 336
	Deficient	Sufficient	
Available Sulphur (S) ($mgkg^{-1}$)	< 10	> 10	
Micronutrients (mg kg-1 soil)	Deficient	Sufficient	
Zinc (Zn)	< 0.6	>0.6	
Copper (Cu)	< 0.2	>0.2	
Iron (Fe)	< 4.5	>4.5	
Manganese (Mn)	< 1.0	>1.0	

Results and Discussion

Soil reaction and electrical conductivity

Soils of the Nethakuppam watershed were slightly acidic to strongly alkaline (6.4 to 8.75) in reaction with a mean pH of 7.7, standard deviation of 0.54 and coefficient of variation of 7.02 per cent (Table 2). Higher soil reaction in the watershed is mainly because of sodicity of soils. The CV of soil pH indicates that spatially it did not vary. while the majority of soils exhibited weakly alkaline to moderate alkaline reaction (7.5-8.5). Neutral to moderate alkalinity may be attributed to the reaction of applied fertilizer material with soil colloids, which results in retention of basic cations on the exchangeable complex of soil. (Sharma *et al.*, 2008) [18] and also strongly supported by Reddy and Naidu (2016) [11].

The EC of soils in Nethakuppam watershed was in the range of 0.01 to 0.581 dSm-1 with a mean of 0.25 dSm-1 and standard deviation of 0.11. The coefficient of variation (42 %) of EC values indicated that salt content in watershed varied spatially (Table 2). Slightly higher level of soluble salts in the study area was due to semi-arid climatic condition. Soluble salt content in the watershed revealed that, the area was non saline. The normal EC may be ascribed to leaching of salts to lower horizons. (Sharma *et al.*, 2008) [18].

Organic carbon

Soil organic carbon content (OC) of Nethakuppam watershed varied from 0.1 to 0.7 per cent with a mean and standard deviation value of 0.30 per cent and 0.13, respectively. The CV of 43 per cent for organic carbon content indicated that, in the watershed organic carbon varied spatially. (Table 2). The reason for low organic carbon content in these soils may be attributed to the prevalence of semi-arid condition, where the degradation of organic matter occurs at a faster rate coupled with little or no addition of organic manures and low vegetation cover on the fields, there by leaving less chances of accumulation of organic carbon in the soils.

Available macro nutrients

The available nitrogen in surface soils of the Nethakuppam watershed varied from 25 to 100 kg ha^{-1} with a mean of 75 and SD of 28. The CV value of 37 per cent indicates that, available N in soils varied spatially. The study revealed that, total area of watershed was low in the available N (Table 2). It is quite obvious that the efficiency of applied nitrogen is very low due to the fact that N is lost through various mechanisms like volatilization (since majority of soils are alkaline), nitrification, denitrification, chemical and microbial fixation leaching and runoff (Datta and Buresh, 1989) [4]. Dwivedi *et al.* (2001) [3].

The available phosphorus content in soils of Nethakuppam watershed ranged from 16 to 245 kg P_2O_5 ha^{-1} with an average and SD value of 62 and 37, respectively. The CV of 59 per cent for available P_2O_5 distribution in the watershed indicates that, it varied spatially (Table 2). Adequate amount of phosphorus in majority of soils may be attributed to continuous application of phosphatic fertilizers to crops and at same time the efficiency of applied phosphorus is very low in soil. Plants take only 10-40 % of applied phosphorus during growing season (Aulakh and Paricha, 1999) [1] and the rest resides in soil as less soluble product.

The available potassium content in soils of Nethakuppam watershed ranged from 243 to 845 kg ha^{-1}, with a mean value of 388 kg ha^{-1} with standard deviation of 91.28 and CV of 23.5 per cent. Most of soils were medium to high in available potassium content. Adequate (medium to high) available K in these soils may be attributed to the prevalence of potassium-rich minerals like illite and feldspars. Due to continuous drain without replenishment over the years deficiency of K has started appearing in certain pockets of the study area. Present results in accordance with (Patil *et al.*, 2011) [10].

The Available sulphur content in soils of Nethakuppam watershed ranged from 0.18 to 29 $kgha^{-1}$ with a mean value of 8.48 kg ha^{-1} with standard deviation of 6.39 kg ha^{-1} and C.V of 75 per cent for available S indicates that, in the watershed available S varied spatially (Table 2). It was observed that the area is divided almost equally between the high and medium status in watershed highlighting the importance of mapping the area rather than the statistics derived from soil analysis. Results are strongly supported by (Mahantesh *et al.*, 2016) [7].

Available micro nutrients

The available Zinc in the watershed ranged from 0.1 to 2.9 mg kg^{-1} with a mean and SD values of 0.55 and 0.36, respectively. The CV of 65 per cent for available zinc indicates that, it varied spatially in the watershed (Table 3). Since, most of the soils are alkaline, low in OC and Similar results were observed by Chandra kant *et al.*, (2019) [2].

The available Copper in the watershed was sufficient and ranged from 0.006 to 8.22 mg kg^{-1} with a mean and SD value of 1.51 and 1.35, respectively. The CV value of 90 per cent for available copper indicates that, it varied spatially in the watershed (Table 3). Satish *et al*., (2018) [15] also observed sufficient status of available copper in soils of soils of Brahmanakotkur watershed.

The available iron content in soils of Nethakuppam watershed ranged from 0.6 to 41 mg kg^{-1} with a mean value of 9 mg kg^{-1}, standard deviation of 6.40 and CV of 71 per cent. The majority area recorded deficient iron content of less than 6 mg kg^{-1} but Nethakuppam watershed registered high mean value and Results in accordance with (Mahantesh *et al*., 2016) [7] and (Satish *et al*., 2018) [15].

The available manganese content of soils of Nethakuppam watershed ranged from 0.65 to 23 mg kg^{-1} with a mean value of 5.15mg kg^{-1}, standard deviation of 4.76 and CV of 92 percent. In general Nethakuppam watershed recorded deficient manganese content and Results in accordance with (Sathish *et al*., 2018) [14].

Table 2: Physico-chemical properties and available major nutrients status in Nethakuppam watershed

	Physico-chemical properties			**Available major nutrients ($kgha^{-1}$)**			
Statistics	pH	EC	OC	N	P	K	S ($mgkg^{-1}$)
Minimum	6.4	0.01	0.1	25	16	243	0.18
Maximum	8.75	0.581	0.7	201	245	845	29
Mean	7.7	0.25	0.30	75	62	388	8
SD	0.5	0.11	0.13	28	37	91	6
C.V (%)	7.0	42.00	43.00	37	59	24	75

Table 3: Available micronutrients status in Nethakuppam watershed

Available micronutrients (mg kg-1 soil)				
Statistics	**Zn**	**Cu**	**Fe**	**Mn**
Minimum	0.1	0.006	0.6	0.65
Maximum	2.92	8.22	41	23
Mean	0.55	1.51	9.0	5.15
SD	0.36	1.32	6.40	4.76
CV (%)	65	90	71	92

Conclusions

From the study, it can be concluded that, soils of Nethakuppam watershed in Ramachandrapuram mandal of Chittoor district of Andhra Pradesh are slightly acidic to strongly alkaline with non-saline. Alkaline soils in the study area need immediate attention for their management to arrest further degradation.

Soil organic carbon content was low to medium. Available N was low, available P_2O_5 was medium to high and K_2O was medium to high, and available S was deficient to sufficient.

Regarding available micro nutrients iron (Fe) and manganese (Mn) were deficient in about $3/4^{th}$ of the watershed area whereas, available copper (Cu) and zinc (Zn) were sufficient in majority area of watershed soils. The fertility status of nutrients in watershed revealed that, available N, S, Fe and manganese are important soil fertility constraints. Indicating their immediate attention for sustained crop production. The deficient micronutrients need to be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients.

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