J. Farm Sci., 32(2): (153-161) 2019

RESEARCH PAPER

Identification and mapping of soil fertility constraints in Dadamatti sub-watershed of Karnataka for site specific recommendations

P. L. PATIL, APPALAL NAIK, H. C. RAMACHANDRAIAH, S. VEERESH, V. JYOTHI, S. T. HUNDEKAR, S. A. GADDANAKERI AND G. S. DASOG

Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dharwad
University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India
E-mail : plpatiluasd@ gmail.com

(Received: January, 2019 ; Accepted: June, 2019)

Abstract: Soil samples from Dadamatti sub-watershed in northern dry zone of Karnataka were drawn at 250 m grid interval and assessed for their fertility parameters. Analytical data was interpreted and statistical parameters like range, mean standard deviation and coefficient of variation were calculated for each parameter. Soil fertility maps were prepared for each parameter under GIS environment using Arc GIS v 10.4. Soils were neutral to very strongly alkaline with non saline to slightly saline. Soil organic carbon content was low to medium. Available nitrogen was low, available phosphorus was low to medium, available potassium was medium to high and sulphur was low to medium. Regarding available micro nutrients, zinc and iron were deficient in about half of the sub-watershed area whereas, copper and manganese were sufficient in the soils. The mapping of nutrients by GIS technique in the sub watershed revealed that, available N, P, Zn and Fe are important soil fertility constraints.

Key words: Nutrients, Soil fertility constraints, Soil fertility map, Watersheds

Introduction

Intensively cultivated soils are being depleted with available nutrients especially micronutrients. Therefore, assessment of nutrient constraints of soils that are being intensively cultivated with high yielding crops needs to be carried out. Soil available nutrients constraints of an area using Global Positioning System (GPS) will help to understand the status of soil fertility spatially and temporally and in formulating site specific balanced nutrient recommendation. Geographic information system (GIS) is a powerful tool which helps to integrate many types of spatial information such as agro-climatic zone, land use, soil management, *etc.,* to derive useful information (Adornado and Yoshida, 2008). It has been documented very well that dryland soils are not only thirsty but hungry too (Wani, 2008) meaning that besides soil and water conservation, if nutrient management issues are addressed, the productivity of a watershed is further enhanced. Some studies on soil fertility status at representative micro–watershed/village level have been carried out at the University of Agricultural Sciences, Dharwad for a few agro ecological zones. Such information is not available for contiguous micro watersheds or for a sub watershed in Karnataka and is essential in planning soil fertility management on a sub watershed area basis. The proposed study was planned with the objective of identifying available nutrients constraints in soils of Dadamatti sub watershed in northern dry zone of Karnataka.

Material and methods

The Dadamatti sub-watershed is located in Vijayapur taluka of Vijayapur district covering an area of 5107.47 ha (Fig. 1) under northern dry zone of agro climatic zones of Karnataka. The sub-watershed is located at about 20 km from Vijayapur city. The sub-watershed consists of eight micro watersheds having undulating topography with a vast degraded open scrub area. The Deccan trap covers the sub-watershed area. The predominant minerals observed in the Deccan trap are ferro-magnesium minerals. The climate of the area is semi-arid or hot tropical and monsoonic type. The average annual rainfall is 580.7 mm. It is well distributed with southwest monsoon (June to September) and northeast monsoon during October and November months. The maximum temperature during summer is 42.7 °C and the minimum 16.1 °C in winter. Mean maximum temperature was 36.56 °C and mean minimum temperature was 20.43 °C.

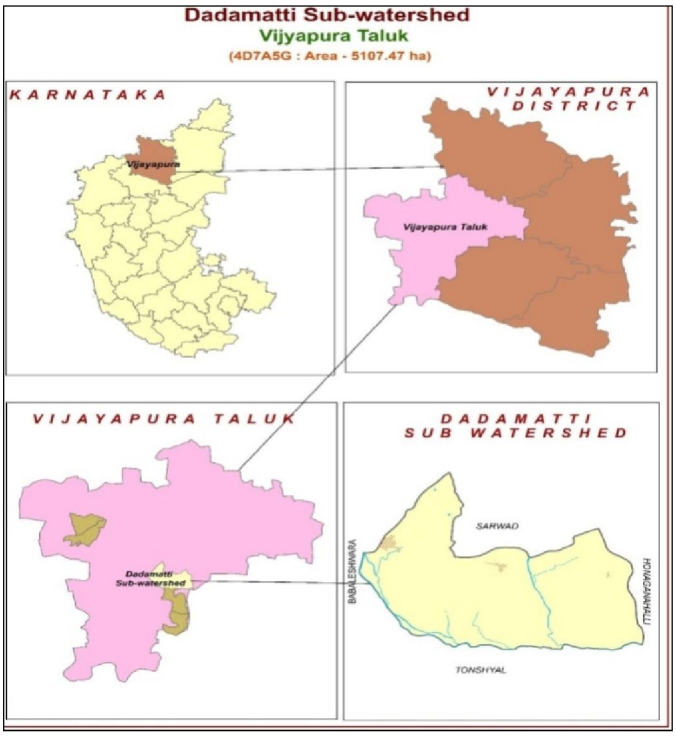

Fig.1. Location map of Dadamatti sub watershed

Surface composite soil samples were collected during April 2018 on grid points of 250 m interval in the study area and the sample location was recorded by GPS. A total of 817 samples were collected from the sub-watershed. Micro watershed wise soil sample details are furnished in Table 1.

The soilsamples were air-dried, ground (< 2 mm) and analysed for soil pH, EC and fertility parameters. The pH (1:2.5) and electrical conductivity (EC) (1:2.5) of soils was measured using standard procedures as described by Jackson (1973). Organic carbon (OC) was determined using the Walkley-Black method (Nelson and Sommers, 1996). Available nitrogen (N) was estimated by modified alkaline permanganate method (Sahrawat and Burford,1982). Available phosphorus was measured by Olsen's method (Olsen and Sommers,1982). Available potassium (K) was determined by the ammonium acetate method (Helmke and Sparks, 1996). Available sulphur (S) was measured using 0.15 % calcium chloride ($CaCl_2$) as anextractant (Tabatabai, 1996). Micronutrients (Fe, Zn, Cu and Mn) were extracted by DTPA reagent using the procedure outlined by Lindsay and Norvell (1978) and estimated by atomic absorption spectroscopy. Variability of data was assessed using mean, standard deviation and coefficient of variation for each set of data. Availability of N, P, K and S in soils are interpreted as low, medium and high and that of available zinc, iron, copper and manganese are interpreted as deficient and sufficient by following the criteria given in Table 2.

A *dbf* file consisting of data for X and Y co-ordinates in respect of sampling site location was created. A shape file (Vector data) showing the outline of Dadamatti sub-watershed area was created in *Arc GIS* 10.4.

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 Dadamatti sub-watershed file was also opened and from the "Surface menu" of Arc GIS geo-statistical Analyst, "geo statistical wizard" option was selected. On the output "grid specification dialogue", output grid extend chosen was same as Dadamatti sub-watershed and the interpolation method employed was krigging. Then map was reclassified based on ratings of the respective nutrients (Table 2) and area for each category of nutrient was calculated.

Table1. Details of soil sampling in Dadamatti sub-watershed (4D7A5G)

Micro watershed	Code	Area (ha)	No. of surface Samples
Sarwad-1	4D7A5G1b	771.34	123
Sarwad-2	4D7A5G1a	589.23	94
Sarwad-3	4D7A5G1c	1003.67	160
Dadamatti-1	4D7A5G2a	937.99	150
Dadamatti-2	4D7A5G2b	555.5	89
Dadamatti-3	4D7A5G2c	530.83	85
Dadamatti-4	4D7A5G2d	722.84	116
		5107.47	817

Table 2. 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})			
Nitrogen (N)	<280	280-560	>560
Phosphorus (P_2O_5)	<22.5	22.5-55	>55
Potassium (K_2O)	<140	140-330	>330
Sulphur (S) (ppm or mg kg^{-1})	<10	10-20	>20
Micronutrients (ppm or mg kg^{-1})	Deficient	Sufficient	
Zinc (Zn)	<0.6	>1.5	
Iron (Fe)	<2.5	>4.5	
Copper (Cu)	<0.2	>5.0	
Manganese (Mn)	<2.0	>4.0	

Results and discussion

Soil reaction and electrical conductivity

Soils of the Dadamatti sub-watershed were alkaline (7.8-9.0) to strongly alkaline (8.4 to 9.0) in reaction with a mean pH of 8.52, standard deviation of 0.24 and coefficient of variation of 3.0 (Table 3). Higher soil reaction in the sub-watershed is mainly because of calcareousness nature and sodicity of the soils (Patil *et al.,* 2018). The coefficient of variation of soil pH indicates that, it did not vary spatially. Mapping of soil pH by GIS technique resulted in two soil reaction classes (Fig. 2). They are; moderately alkaline (7.8-8.4) and strongly alkaline (8.4 to 9.0). Major proportion of the sub-watershed area (Fig. 2) was strongly alkaline (83.59 %) and remaining area was moderately alkaline (13.66 %). The higher pH of soils could be attributed to low intensity of leaching and accumulation of bases. (Ravikumar *et al.,* 2007a, Prabhavati *et al.,* 2015 and Patil *et al.,* 2016). Strongly alkaline area is to be reclaimed by application of gypsum based on gypsum requirement of soil and leaching of sodium with good quality water or rain water harvested by compartment bunding. Alkalinity tolerant crops may be grown.

The EC of soils in the sub-watershed was in the range of 0.08-8.40 dS m^{-1} with mean value of 0.31 dS $m^{-1}$and standard deviation of 0.41. The CV (133) of EC values indicate that salt content in the sub-watershed vary spatially. Higher level of soluble salts in the study area is due to arid climatic condition

Table 3. Chemical properties and available major nutrients status in Dadamatti sub-watershed

	pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	S (mg kg^{-1})
Average	8.52	0.31	0.46	156	44.5	607	12.4
SD	0.24	0.41	0.13	28	10.9	162	4.9
Range	7.4-9.3	0.08-8.40	0.16-0.9	112-268	20-96	252-1135	4.1-39.4
C.V.(%)	3.0	133	28.0	18.0	25.00	27.0	39.0

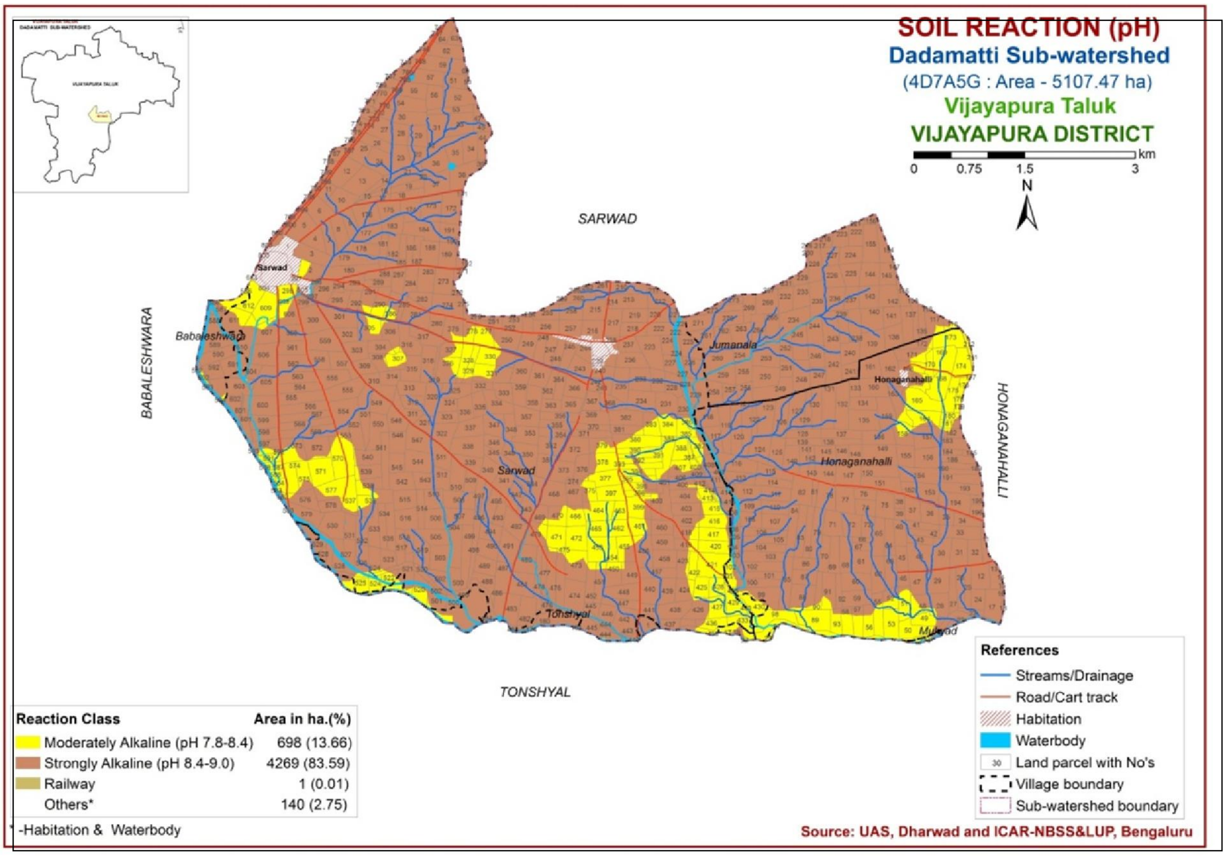

Fig. 2. Soil reaction status of Dadamatti sub-watershed

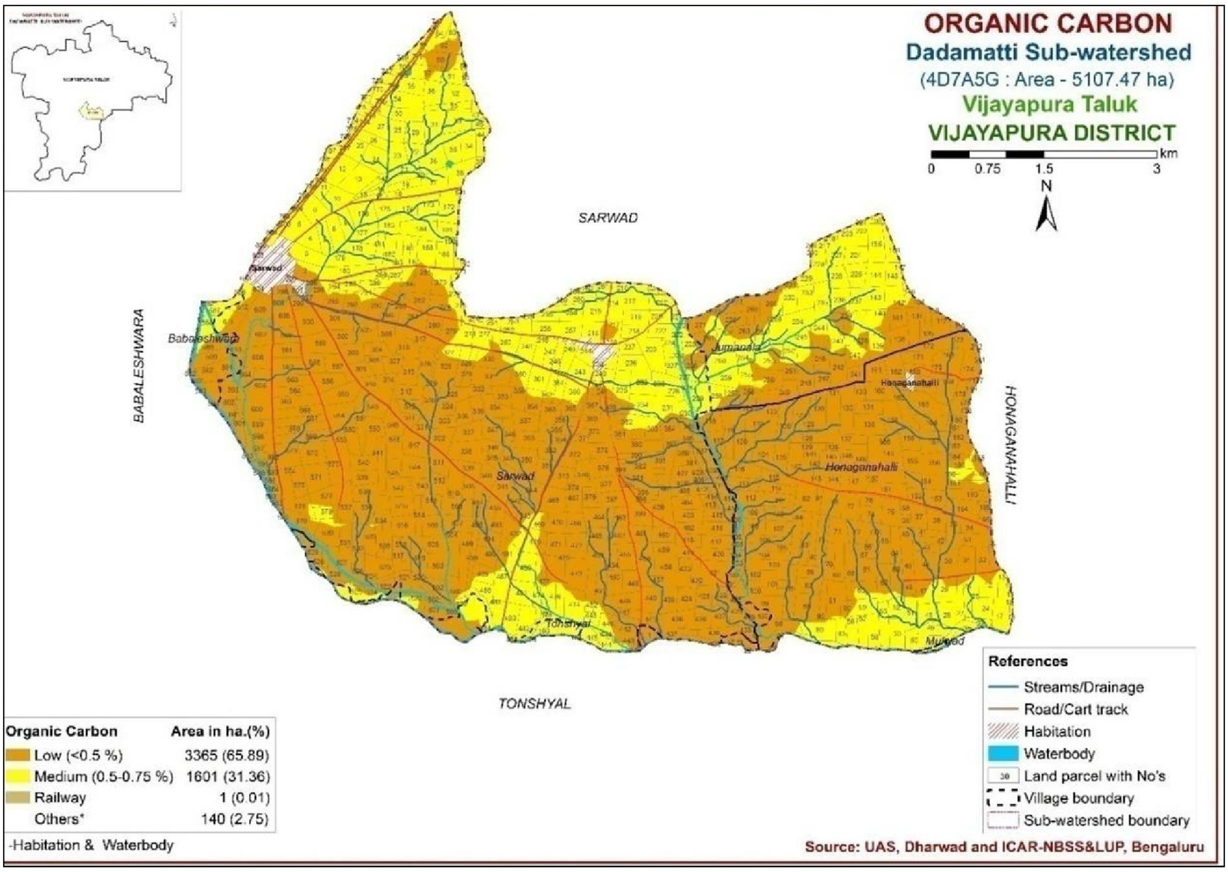

Fig. 3. Soil organic carbon status of Dadamatti sub-watershed

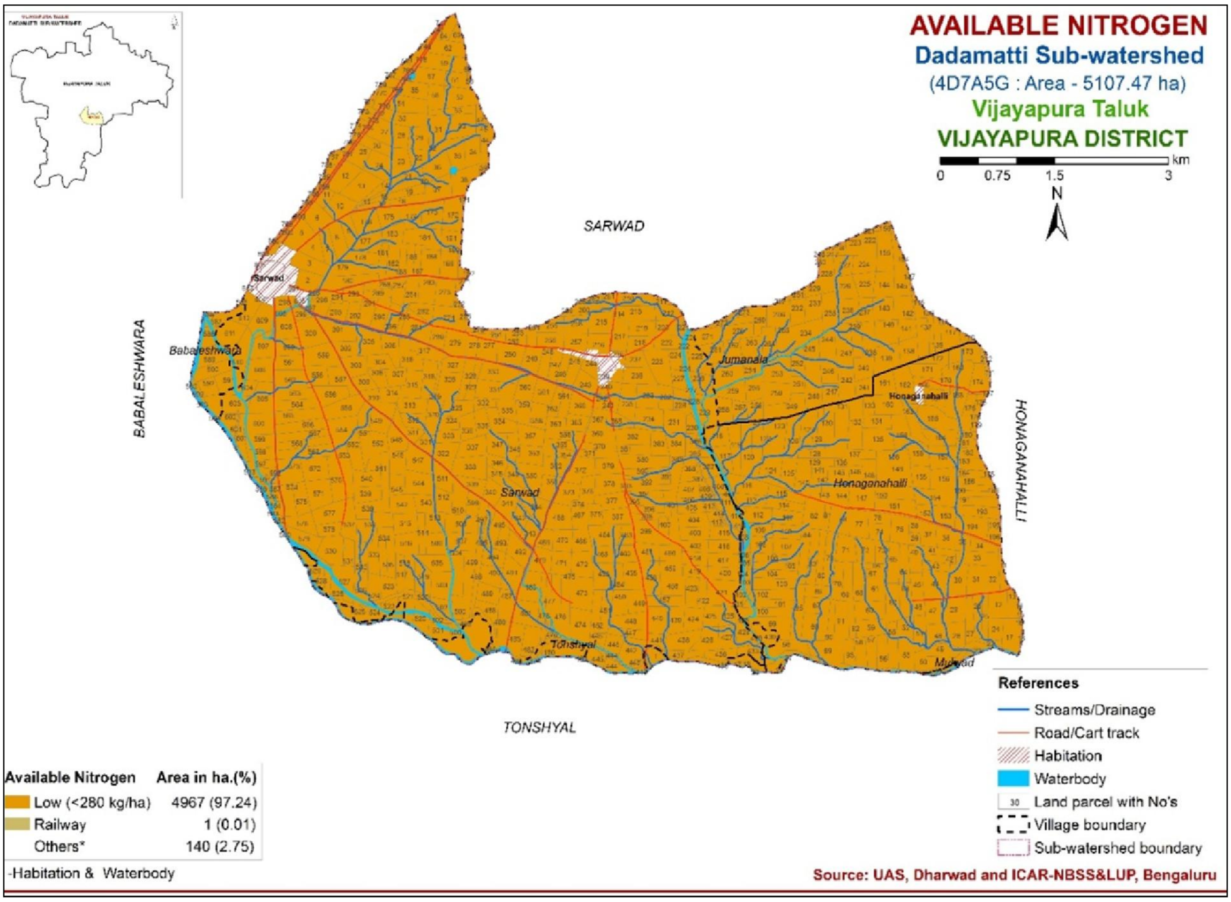

Fig. 4. Available nitrogen status of Dadamatti sub-watershed

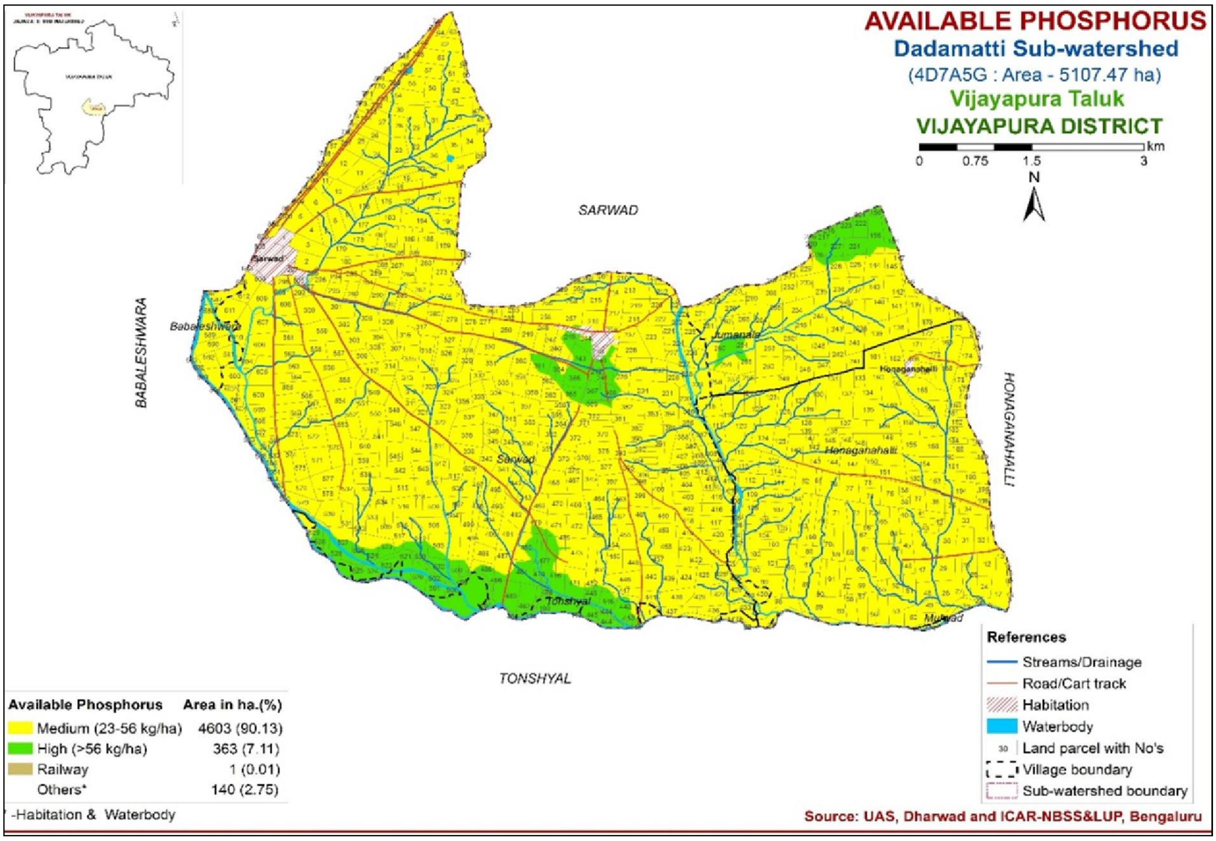

Fig. 5. Available phosphorus status of Dadamatti sub-watershed

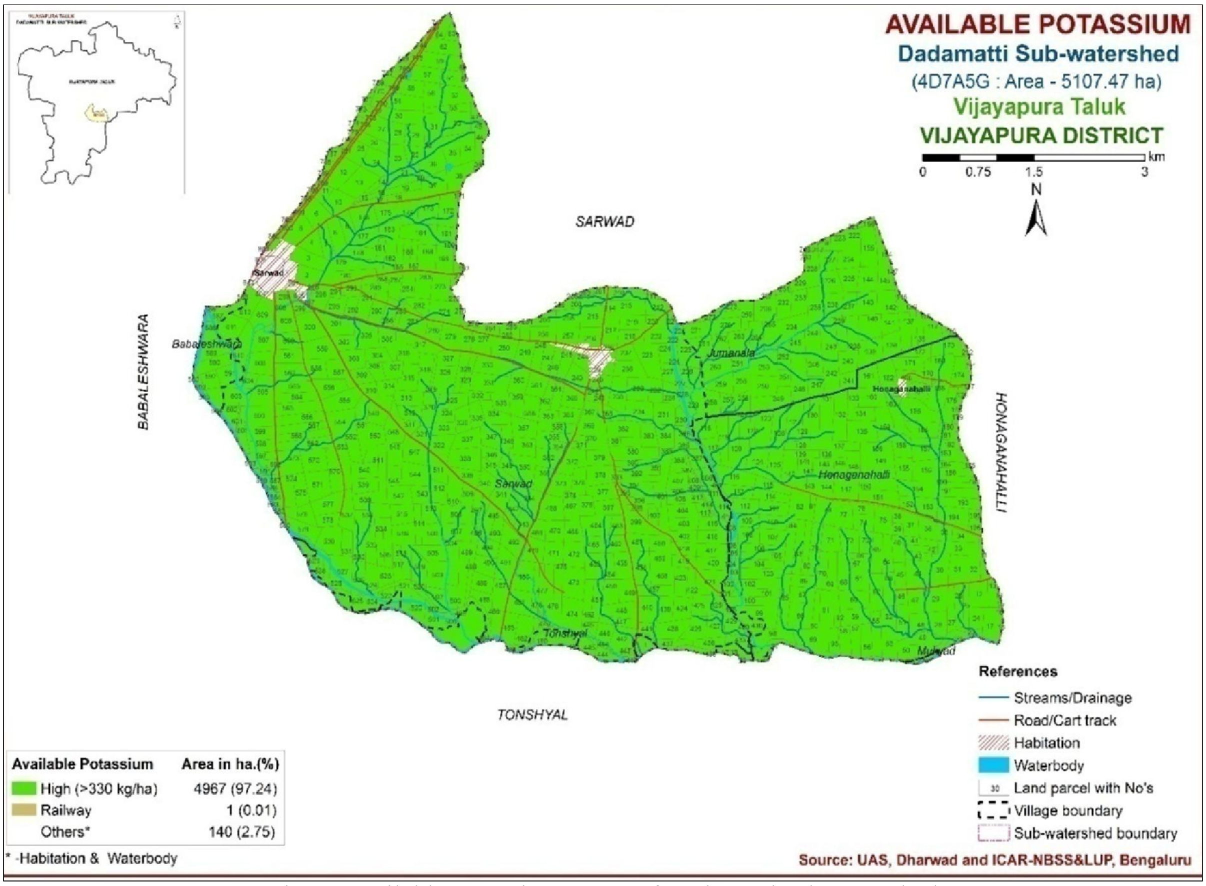

Fig. 6. Available potassium status of Dadamatti sub-watershed

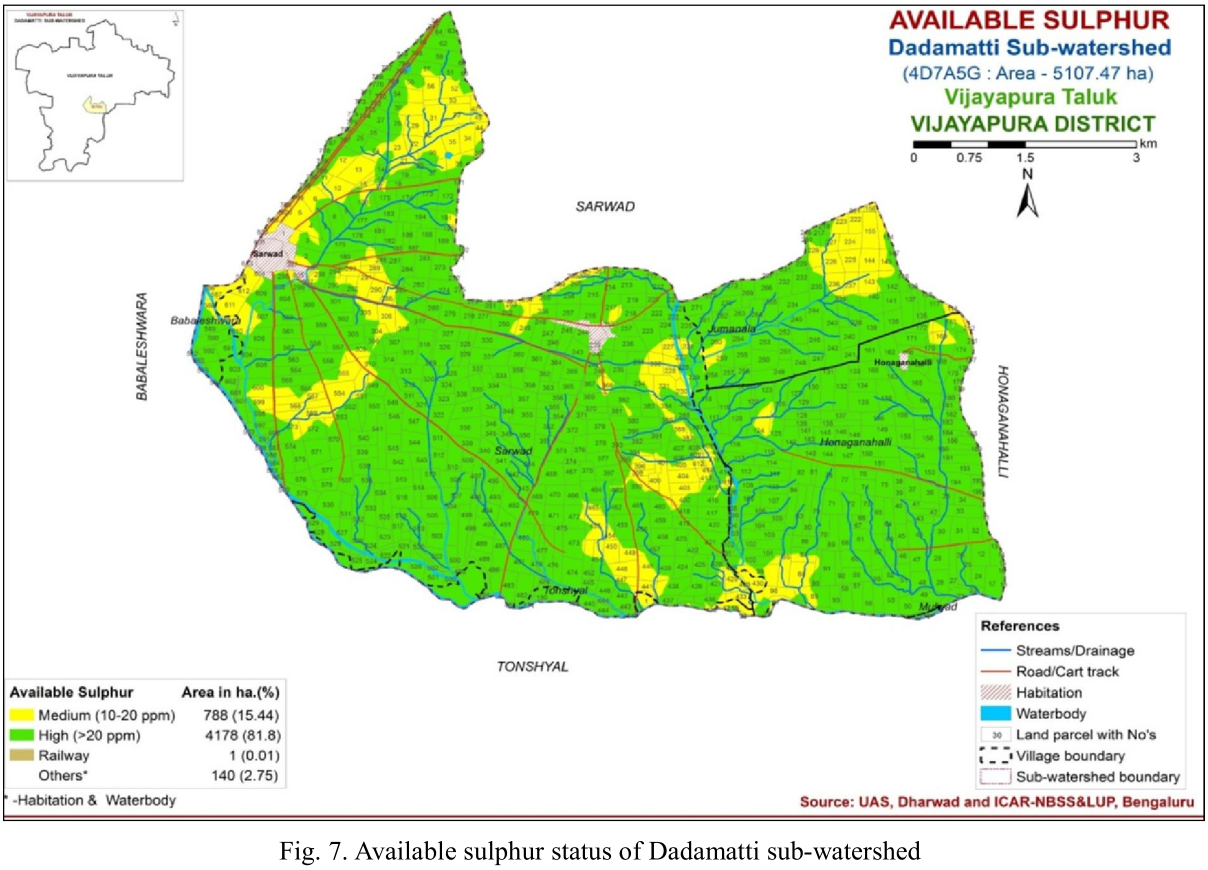

Fig. 7. Available sulphur status of Dadamatti sub-watershed

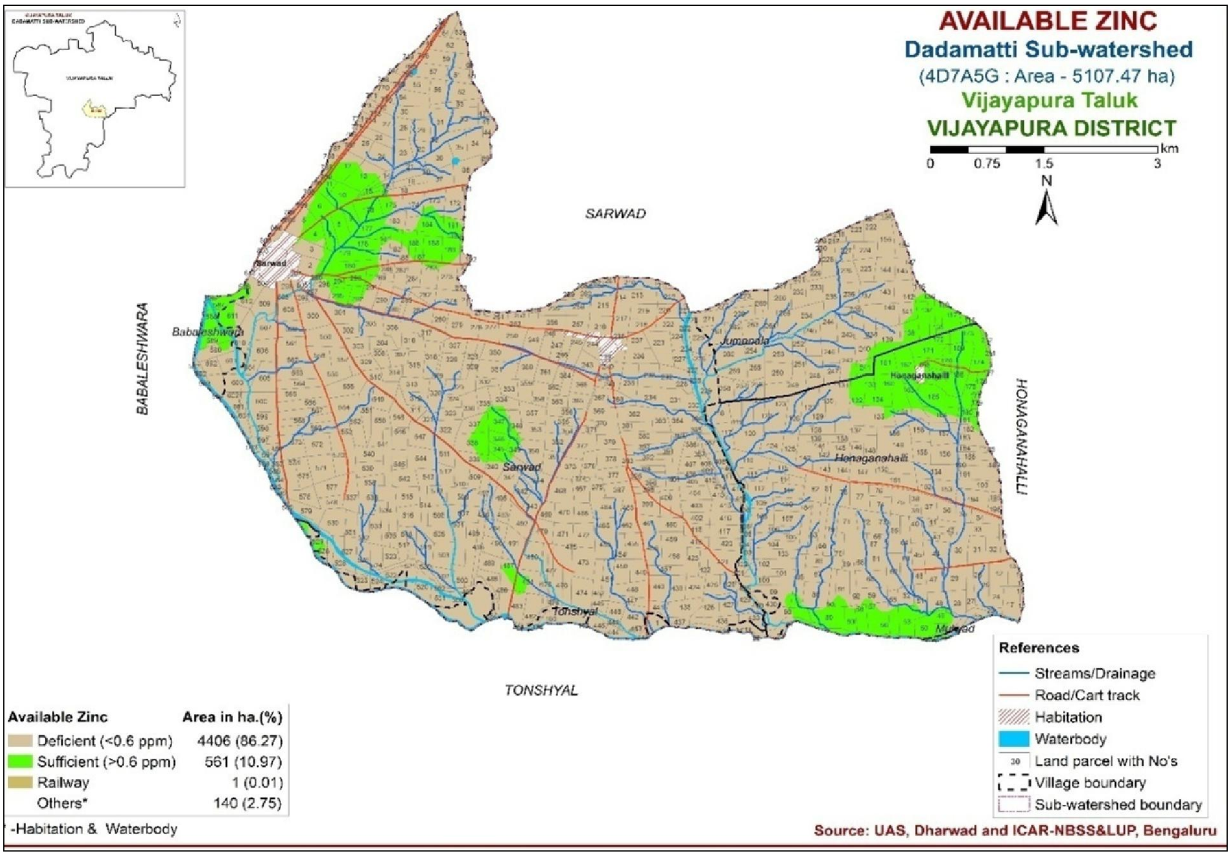

Fig. 8. Available zinc status of Dadamatti sub-watershed

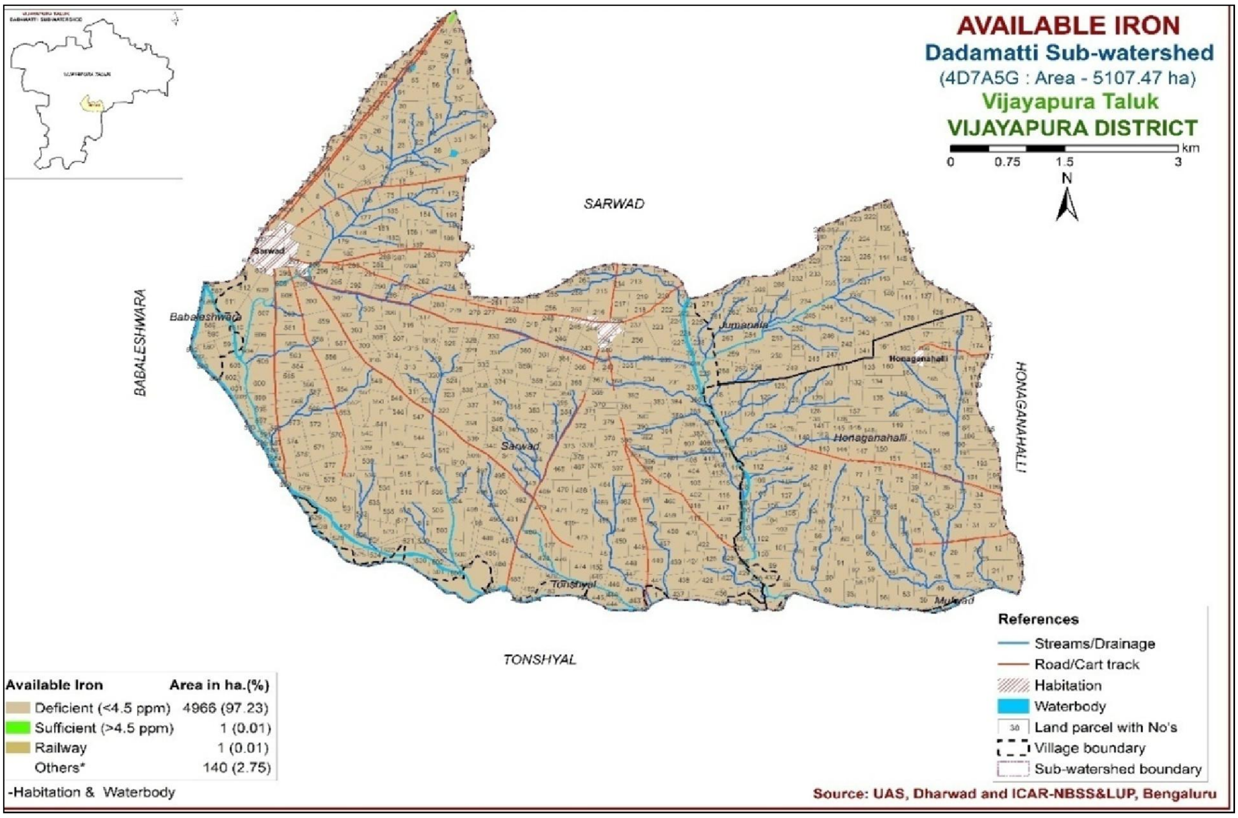

Fig. 9. Available iron status of Dadamatti sub-watershed

(Srikant *et al.,* 2008 and Patil *et al.,* 2016). GIS Mapping of soluble salt content in the sub-watershed revealed that, 88.1 per cent of the area was non saline whereas, 8.9 per cent of the area was slightly saline and 1.2 per cent of the area was marginally saline. Although higher salinity is measured in the sub-watershed, it is not detected when mapped by GIS technique, this is due to less number of locations with higher salinity which are averaged during the process of krigging in GIS mapping.

Organic carbon

Organic carbon content of soils of Dadamatti sub-watershed ranged from 0.16 to 0.9 per cent with mean and standard deviation values of 0.46 and 0.13 per cent, respectively. The CV (28.0) for OC content indicates that, in the sub-watershed SOC varied spatially (Table 3). Mapping of OC by GIS revealed that soil organic carbon is low in 66 per cent of TGA and medium in 31 per cent of TGA (Fig. 3). Although higher SOC (> 0.75%) is measured in the sub-watershed, it is not detected when mapped by GIS technique, this is due to less number of locations with higher SOC which are averaged during the process of krigging in GIS mapping. The values obtained in the present study are in agreement with those reported by Ravikumar *et al.* (2007a) and Patil *et al*. (2011) for the soils of Malaprabha command area of Karnataka. The reason for low organic carbon content in these soils may be attributed to the prevalence of arid condition, where the degradation of organic matter occur at a faster rate coupled with little or no addition of organic manures and low vegetative cover on the fields, thereby leaving less chances of accumulation of organic carbon in the soils. Intensive cropping is also one of the reasons for low organic carbon content. The similar results were also reported by Srikant *et al.* (2008), Prabhavati *et al.* (2015) and Patil *et al.* (2016) for the soils of northern dry zone of Karnataka. Soil organic carbon status of soils is to be enhanced by crop residue management for improving physical, chemical and biological properties and fertility status of soils.

Available macronutrients

The available N in soils of the sub watershed ranged from 112 to 268 kg ha^{-1} with a mean of 156 kg ha^{-1} and SD of 28. The CV value of 18.0 indicates that available N in soils did not vary spatially. The GIS mapping revealed that, the entire sub-watershed was low in the available nitrogen (Table 3 and Fig. 4). The low N content could be attributed to soil management, varied application of FYM and fertilizer to previous crops. Nitrogen is the most limiting nutrient in black soils as its availability decreases due to fixation and volatilization losses. Another possible reason may also be due to low organic matter content in these areas due to low rainfall and high temperature which facilitate faster degradation and removal of organic matter leading to nitrogen deficiency. Similar nitrogen status was reported by Srikant *et al.* (2008), Pulakeshi *et al.* (2012) and Patil *et al*. (2016) in non-saline clay to sandy loams and calcareous soils of northern Karnataka. Mapping by GIS technique revealed that, the soils of the entire area was low in available nitrogen status. Crops are to be supplied with 25 per cent more than the recommended dose of N. Use of bio fertilizers for seed treatment may be popularised for increasing N supply to the crops. In wider row spacing crops, sunhemp may be grown and incorporated at flowering stage.

The available P_2O_5content of the sub-watershed ranged from 20 to 96 kg ha^{-1} with average and SD values of 44 and 10.9 kg ha^{-1}, respectively. The CV (25.0) for available P_2O_5 distribution in the sub watershed indicates that, it varied spatially. Mapping of available $P_2O_5$by GIS revealed that, available P_2O_5in soils is medium in 90 per cent of TGA (Table 3 and Fig. 5). Medium P_2O_5 availability in these soils is related to their high pH, calcareousness and low organic matter content. The present findings are in line with those of Srikant *et al.* (2008) who reported that majority of the soils in north Karnataka were low to medium in phosphorus content due to high pH and calcareousness. Use of P solubilizers may be popularised for increasing P availability to crops.

The available K_2O content in the sub-watershed ranged from 252 to1135 kg ha^{-1} with mean and SD values of 607 and 162 kg ha^{-1}, respectively. The CV (27.0) for available K_2O content indicates that, it varied spatially in the sub-watershed. Mapping of available K_2O content in the sub watershed by GIS revealed that, entire study area was in high category (Table 3 and Fig. 6). It is reported that, invariably the surface soils had higher concentration of water soluble and exchangeable K in Karnataka (Patil *et al.,* 2011). Soils are able to maintain a sufficient or even high level of exchangeable K and provide a good supply of K to plants for many years. The higher content of available potassium in soils of Dadamatti sub-watershed may be due to the predominance of potash rich micaceous and feldspar minerals in parent material. Similar results were observed by Srikant *et al.* (2008).

The available sulphur content of soils of the sub-watershed varied from 4.1 to 39.4 mg kg^{-1} soil with mean and SD values of 12.4 and 4.9 mg kg^{-1} soil, respectively. The CV (39.0) for available S content indicates that, in the sub-watershed available S varied spatially (Table 3). GIS mapping of available S revealed that (Fig 7), available sulphur in soils was medium (15 % of TGA) to high (82 % of TGA). Similar results were observed by Patil *et al.* (2016) for soils of Gadag district in northern dry zone of Karnataka.

Available micro nutrients

The available zinc in the sub-watershed ranged from 0.15 to 3.0 mg kg^{-1} with mean and SD values of 0.45 and 0.26 mg kg^{-1}, respectively (Table 4). The CV (58) for available Zn content indicates that, it varied spatially in the sub-watershed. Mapping of available Zn by GIS revealed that, it was deficient in the 86 per cent of the study area and sufficient in 11 per cent of the area (Fig. 8). The content of Zn increases with low pH and high organic carbon content but decreases with increase in pH. Since, the most of the soils are alkaline, low in OC and dominated by $CaCO_3$, zinc may be precipitated as hydroxides and carbonates as a result, their solubility and mobility might have decreased and reduced the availability. Similar results were reported by

Table 4. Available micro nutrients status in Dadamatti sub watershed

	Zn	Fe	Mn	Cu
		mg kg^{-1}		
Average	0.45	2.33	2.85	0.82
SD	0.26	1.43	1.76	0.37
Range	0.15-3.0	0.15-7.90	0.19-10.70	0.05-2.0
CV	58	62	62	45

Ravikumar *et al.* (2007b), Patil *et al.* (2006) Pulakeshi *et al.* (2012) and Patil *et al.* (2016).

The available iron in the sub-watershed ranged from 0.15 to 7.90 mg kg^{-1} with mean and SD values of 2.33 and 1.43 mg kg^{-1}, respectively (Table 4). The CV (62) for available Fe content indicates that, it varied spatially in the sub-watershed. Mapping of available Fe by GIS revealed that, available iron is deficient in 97 per cent of TGA (Fig. 9). The low Fe content may be due to precipitation of Fe by $CaCO_3$ and decreased its availability. Similar, results were also observed by Patil *et al.* (2006),Ravikumar *et al.*(2007b),and Patil *et al.* (2016). The variation of available iron in surface soils may be due to the soil management practices and cropping pattern adopted by different farmers. The area deficient in Fe is to be supplied with 10-25 kg /ha ferrous sulphate after curing with well decomposed manure at 1:1 ratio.

The available Manganese in the sub-watershed ranged from 0.19 to 10.70 mg kg^{-1} with mean and SD values of 2.85 and 1.76 mg kg^{-1}, respectively (Table 4). The CV (62) for available Mn content indicates that,it varied spatially in the sub-watershed. Mapping of available Mn by GIS revealed that, it was sufficient in the entire study area. Sufficient content of manganese was observed by Ravikumar *et al.* (2007b) in Vertisols of Malaprabha command area, Pulakeshi *et al.* (2012) and Patil *et al.* (2016) in the soils of northern Karnataka derived from chlorite schist.

The available copper in the entire sub-watershed was sufficient and ranged from 0.05 to 2.0 mg kg^{-1} with mean and SD value of 0.82 and 0.37 mg kg^{-1}, respectively (Table 4). The CV (45) for available Cu content indicates that, it varied spatially in the sub-watershed. Mapping of available Cu by GIS revealed that, it was sufficient in the entirestudy area. Ravikumar *et al.* (2007b), Pulakeshi *et al.* (2012) and Patil *et al.* (2016) also observed sufficient status of available copper in soils of north Karnataka.

Conclusion

From the study, it can be concluded that, soils of Dadamatti sub-watershed in northern dry zone of Karnataka are neutral to very strongly alkaline with non saline to slightly 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 nitrogen was low, available phosphorus was medium, available potassium was high and sulphur was medium to high. Regarding available micronutrients, zinc and iron were deficient in the entire sub-watershed area whereas, copper and manganese were sufficient in the soils. The mapping of nutrients by GIS technique in the sub-watershed revealed that OC, available N, Zn and Fe are important soil fertility constraints indicating their immediate attention for sustained crop production. The deficient micronutrient need to be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients.

Acknowledgement

The study is part of the Sujala-III project funded by World Bank through Government of Karnataka. The authors duly acknowledge the support.

References

Adornado H A and Yoshida M, 2008, Crop suitabilityand soil fertility mapping using geographic informationsystem (GIS). *Agricultural Information Research,*17: 60-68.

Helmke P A and Sparks D L, 1996, Lithium, sodium,potassium, rubidium and cesium. In: *Methods of Soil Analysis,* Part 3, *Chemical Methods* (Ed. D L Sparks). Madison, Wisc.: SSSA and ASA, pp.551-574.

Jackson M L, 1973, Soil Chemical Analysis. 1st Edn., Prentice Hall Ltd., New Delhi, India.

Lindsay W L and Norvell W A, 1978, Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science and Society of America Journal,* 42: 421-428.

Nelson D W and Sommers L E, 1996, Total carbon, organiccarbon, and organic matter. In: *Methods of Soil Analysis*, Part 3. *Chemical Methods* (Ed. D L Sparks). Madison, Wisc. SSSA and ASA, pp. 961-1010.

Olsen S R and Sommers L E, 1982, Phosphorus. In: *Methodsof Soil Analysis* (Eds. A L Page *et al.,*), Part 2, 2nd edition, Madison, Wisconsin. American Society of Agronomy and Soil Science Society of America, pp. 403-430.

Patil P L, Kuligod V B, Gundlur S S, Katti Jahnavi, Nagaral I N, Shikrashetti P, Geetanjali H M and Dasog G S, 2016, Soil fertility mapping in dindur sub-watershed of Karnataka for site specific recommendations. *Journal of the Indian Society of Soil Science,* 64: 381-390.

Patil P L, Radder B M, Patil S G, Aladakatti Y R, Meti C B and Khot A B, 2006, Response of maize to micronutrients and moisture regimes in Vertisols of Malaprabha Command, Karnataka *Journal of the Indian Society of Soil Science,* 54: 261-264.

Patil P L, Radder B M and Aladakatti Y R, 2011, Effect of moisture regimes, zinc and iron levels on yield, WUE and nutrients uptake in chilli + cotton cropping system. *Journal of the Indian Society of Soil Science,* 59: 401-406.

Patil P L, Dasog G S, Ramachandraiah H C, Pratibha K S, Devarnavadagi V S,Veeresh S, Appalal Naik, Hundekar S T, Pathak S D and Rajiv Ranjan, 2018, Land resource inventory of Hirehalla sub-watershed (4D7A8b) using remote sensing and GIS techniques for watershed development, In: *Proceedings of National Conference on Application of Geo-Spatial Technologies and ICTs in Smart Agriculture (SMARTAGRI-2018),* (Eds. Patil *et al.,* 2018), UAS, Dharwad, 23-24, January 2018, pp. 30-35.

Prabhavati K, Dasog G S, Patil P L, Sahrawat K L and Wani S P, 2015, Soil fertility mapping using GIS in three agro-climatic zones of Belgaum district, Karnataka. *Jornal of the Indian Society of Soil Science,* 63: 173-180.

Pulakeshi P H B, Patil P L, Dasog G S, Radder B M, Bidari B I and Mansur C P, 2012, Mapping of nuntrients status by geographic information system (GIS) in Mantagani village under northern transition zone of Karnataka. *Karnataka Journal of Agricultural Sciences,* 25: 332-335.

Ravikumar M A, Patil P L and Dasog G S, 2007a, Mapping of nutrients status of 48A distributary of Malaprabha right bank command of Karnataka by GIS technique. I-Major nutrients. *Karnataka Journal of Agricultural Sciences,* 20: 735-737.

Ravikumar M A, Patil P L and Dasog G S, 2007b, Mapping of nutrients status of 48A distributary of Malaprabha right bank command of Karnataka by GIS technique. II-Micro nutrients. *Karnataka Journal of Agricutlural Sciences,* 20: 738-740.

Sahrawat K L and Burford J R,1982, Modification of alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. *Soil Science,*133: 53-57.

Srikant K S, Patil P L and Dasog G S and Gali S K, 2008, Mapping of available major nutrients of a micro watershed in northern dry zone of Karnataka. *Karnataka Journal of Agricultural Sciences,* 21: 391-395.

Tabatabai M A,1996, Sulfur. In: *Methods of Soil Analysis,* Part 3. *Chemical Methods* (Ed. D L Sparks). Madison, Wisconsin. American Society ofAgronomy and Soil Science Society of America, pp.921-960.

Wani S P, 2008, Taking soil science to farmers' door steps through community watershed management. *Journal of the Indian Society of Soil Science,* 56: 367-377.