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Soil fertility mapping of the Khanapur micro-watershed using GIS in hilly agro-climatic zone (Zone 9) of Belgaum district

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Abstract
The Belgaum district is located east of the Western Ghats and is situated in the northwestern part of Karnataka state. The Khanapur micro-watershed (4D7C9L1c) was selected representing the Hilly agro-climatic zone (zone 9) of the district. A total of 60 surface samples in the Khanapur micro-watershed were thus collected from the sample points fixed by imposing grids at 10” interval on the selected micro-watershed and analysed for chemical characteristics and fertility status. Forest occupy an area of 151.20 ha which accounts for 25.79 percent of the total geographical area (586.24 ha) of Khanapur micro-watershed. Agricultural land use in Khanapur micro-watershed occupied the major portion (69.33 percent) of TGA. A small area of 28.57 ha land was under sheet rock. The forest and agricultural land use in Khanapur micro-watershed had shown slightly acidic soil reaction. The organic carbon content in forest land use of Khanapur micro-watershed was of high category with a mean value of 8.0 g kg^{-1}. Whereas, the agricultural land exhibited medium category of organic carbon with a mean value of 6.5 g kg^{-1}. Majority of the area (81.18 percent) in Khanapur watershed was under medium category of available nitrogen. 71.68 percent amounting to 42.2 ha area in Khanapur micro-watershed was under low category of available phosphorus. Low and medium categories of available potassium were observed in Khanapur micro-watershed in 49.8 percent (291.8 ha) and 50.2 percent (294.4 ha) area of TGA.

Keywords: GIS, agro-climatic zones, soil fertility map, watershed

Introduction

Soils and land are fixed natural resources, whereas their use is diversified for different purposes which modify the ecology of the region. Land is used for agriculture and forest production, infrastructure, genes reserve and production, geogenic and cultural heritage forming landscapes and source of raw materials.

Soil systems like most natural systems, are in dynamic equilibrium. Most changes are slow and imperceptible particularly when viewed in the time frame of human lifespan. However, changes occur in fertility status of soils due to human interference like land use, intensive cultivation and imbalanced fertilization as well as nature events such as high intensity storms which accelerate erosion processes resulting in changes which are measurable directly or indirectly or may be inferred from behaviour of the system. More than ninety percent of world’s food production is dependent on soil (Venkataratnam & Manchanda 1997) [15] and fertilizer management is a major consideration in agricultural production. Inadequate fertilizer application limits crop yield, results in nutrient mining and causes soil fertility depletion. An excessive or imbalanced application not only wastes a limited resource, but also pollutes the environment. With consideration of both economic optimization and environmental concerns, farmers are forced to face with an ever-increasing demand for effective soil fertility management. An approach towards justifying such concerns is site specific nutrient management– which takes into account spatial variations in nutrients status cutting down the possibility of over or under use of fertilizer. There have been growing interests in the study of spatial variation of soil characteristics and it was shown that the soil status of the major nutrients as well as organic matter and clay contents is spatially variable within a single small sized paddy field (Moritsuka *et al*. 2004) [5] also found that a site-specific soil management would increase nutrient efficiency and crop productivity. Belgaum district has three agro-climatic zones (zone 3, 8 and 9) and however, relatively few studies have thoroughly investigated the spatial variability of soil chemical characteristics in micro-watersheds and hence keeping these factors in view, the present study was undertaken to map the spatial distribution of soil fertility of selected watershed representing the hilly agro-climatic zones of

Belgaum district.

Materials and Methods

The Belgaum district is located east of the Western Ghats and is situated in the northwestern part of Karnataka state. The Khanapur micro-watershed (4D7C9L1c) was selected representing the Hilly agro-climatic zone (zone 9) of the district. The Khanapur micro-watershed is located between $15^0$36'30" to $15^0$38'0" N latitude and $74^0$31'10" to $74^0$32'30" E longitude with an average elevation of 682 m above Mean Sea Level. The geographical area of Khanapur micro-watershed is 586.2 ha. The climate of the Khanapur micro-watershed is sub-humid with mean annual rainfall of 1859.1 mm.

Surface samples were collected using hand held GPS by adopting grid sampling in the study area. A total of 60 samples in the Khanapur micro-watershed were thus collected from the sample points fixed by imposing grids at 10" interval on the selected micro-watershed and analysed for chemical characteristics and fertility status. These surface soil samples were analyzed for pH, EC, OC and available macronutrients (N, P, K and S) as well as micronutrients (Fe, Zn, Cu and Mn) by adopting standard procedures outlined by Jackson (1973) [3] and Lindsay and Norvell (1978) [4], respectively. Spatial variability is a term indicating changes in the value of a given property over space (Ettema and Wardle, 2002) [2]. It can be assessed using classical descriptive statistics (i.e., mean, range, standard error of mean). Descriptive statistics, including the mean, range, standard error (SE) were determined for each set of data.

Preparation of soil fertility maps using GIS techniques

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 Khanapur micro-watershed area was created separately in *Arc GIS 10.0*.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 respective micro-watershed file was also opened and from the ``Surface menu`` of Arc GIS geo statistical analyst "geostatistical wizard`` option was selected. On the output "grid specification dialogue", output grid extend chosen was same as micro-watershed area and the interpolation method employed was kriging. Kriging is common geostatisical procedure that has been used for optimal estimation and spatial interpolation of values at unsampled locations. Then map was reclassified based on ratings of the respective nutrients. .

Results and Discussion

Forest occupy an area of 151.20 ha which accounts for 25.79 percent of the total geographical area (586.24 ha) of Khanapur micro-watershed. Agricultural land use in Khanapur micro-watershed occupied the major portion (69.33 percent) of TGA. A small area of 28.57 ha land was under sheet rock. The LISS-III image and the land use / land cover map of the Khanapur micro-watershed are presented in fig 1. The land cover statistics derived from the interpretation is presented in Table 1. Chemical properties and fertility status of micro-watersheds are presented in Table 2 and their spatial distribution is presented in Table 4. Chemical properties and fertility status as per the land use in Khanapur micro-watersheds are presented in Table 3.

Soil reaction

The soils of Khanapur micro-watershed had exhibited pH varied between 4.98 and 6.99 revealing the acidic soil reaction due to leaching of bases because of high annual rainfall at Khanapur. The forest and agricultural land use in Khanapur micro-watershed had shown slightly acidic soil reaction with slightly lower pH value (5.75) in forest area compared to agricultural land (6.10). The reason might be the organic acids released during decomposition of organic matter added from leaf litter in forest land use.

Electrical conductivity

Electrical conductivity (EC) of all the land uses in the micro-watershed was in normal range and therefore all the soils were within the safe limits of salinity on the basis of limits suggested by Muhr *et al*. (1963) [6] for judging salt problem of soils (EC < 1dSm^{-1} as 'normal' and EC 1-2 dSm^{-1} as critical for germination).

Organic carbon

The area under low, medium and high category for organic carbon was 46.12 ha (7.87 %), 152.13 ha (25.95 %) and 387.99 (66.18 percent), respectively in Khanapur micro-watershed. Higher organic carbon content is due to high rainfall and forest vegetation prevailing there. The organic carbon content in forest land use of Khanapur micro-watershed was of high category with a mean value of 8.0 g kg^{-1}. Whereas, the agricultural land exhibited medium category of organic carbon with a mean value of 6.5 g kg^{-1}. The higher value of organic carbon in forest land use was probably because of addition of litter and slower oxidation of the fresh organic material (Sojka and Upchurch, 1999; Seybold *et al*., 1999) [14, 1].

Higher organic carbon stock was observed in surface soils under agricultural land of Khanapur micro-watershed (14.58 t ha^{-1}) because of higher annual rainfall observed in Khanapur area (1944.31 mm). It could also be ascribed to slow microbial activity under low temperature and acidic environment (Sarkar *et al*., 2002).The organic carbon stock in Khanapur micro-watershed differed markedly with respect to land use showing higher OC stock in forest land use (18 t ha^{-1}) than agricultural land (14.58 t ha^{-1}). The results are in line with findings of Singh and Ganeshmurthy (1991) [12]. Cultivation accelerated oxidation of organic matter resulting in rapid decomposition of crop residues and organic sources (Doran and Smith, 1987) [1].

Available macronutrients

Majority of the area (81.18 percent) in Khanapur watershed was under medium category of available nitrogen reflecting the trends of organic carbon observed in these soils and the climatic conditions prevailing in these soils. In Khanapur micro-watershed, forest land use had higher available nitrogen with a mean value of 474.9 kg ha^{-1} than corresponding agricultural land (390.3 kg ha^{-1}). This might be because of high organic carbon status under forest land.

71.68 percent amounting to 42.2 ha area in Khanapur micro-watershed was under low category of available phosphorus while, 14.31 percent (83.9 ha) and 14.01 percent (82.1 ha) area was under medium and high category, respectively. This could be attributed to the fixation of released phosphorus by clay minerals and oxides of iron and aluminium (Vijay Kumar *et al*. 1994) [16]. The forest land use in Khanapur micro-watershed recorded low available phosphorus (7.91 kg ha^{-1}) against the limit of < 22.5 kg ha^{-1} considered under low category. Whereas, the available phosphorus content in agricultural land was medium (34.02 kg ha^{-1}) and it might be because of application of high phosphorus analysis fertilizer like DAP for crops under cultivation.

Low and medium categories of available potassium were observed in Khanapur micro-watershed in 49.8 percent (291.8 ha) and 50.2 percent (294.4 ha) area of TGA. The Kaolinitic type of clay mineralogy in the soils might be the cause for medium and low ratings. Low available potassium status (172.87 kg ha^{-1}) was observed under agricultural land use in Khanapur micro-watershed. Whereas, the forest land recorded medium status of available potassium (201.82 kg ha^{-1}). The decline in soil nutrients, especially available nitrogen and potassium, may be due to exhaustion by the crops under cultivation without adequate replenishment and with depletion of organic matter levels. Singh *et al*. (1987) [13] also reported a noticeable decrease in organic carbon, available nitrogen and potassium due to change in land use pattern in soils under tropical rain forest in Andaman.

In Khanapur micro-watershed, the area under low and medium category of available sulphur was 289.82 ha (49.44 %) and 296.42 ha (50.56 %), respectively due to the lack of sulphur addition and continuous removal of sulphur by crops. The forest land use in Khanapur micro-watershed had shown medium category of available sulphur (10.52 mg kg^{-1}) against the limit of <10 mg kg^{-1}which is considered to be low category. Whereas, low available sulphur status was observed in agricultural land.

DTPA extractable micronutrients

The forest land use in Khanapur micro-watershed had shown mean DTPA extractable zinc value of 0.67 mg kg^{-1} which falls under sufficient range. Whereas, the agricultural land recorded little higher mean value of DTPA extractable zinc (0.76 mg kg^{-1}). The reason might be the application of zinc to the crops under cultivation.

The DTPA extractable iron was in sufficient range in soils of Khanapur micro-watershed under forest as well as agricultural land use. The organic carbon due to its affinity to influence the availability of iron by chelating action might have protected the iron from oxidation and precipitation, which consequently increased the iron in surface soils (Prasad and Sakal 1991) [7].

The DTPA extractable manganese was found to be sufficient against the critical level 1.0 mg kg^{-1} (Lindsay and Norvell, 1978) [4] in forest land use as well as agricultural lands of Khanapur micro-watershed. It may be due to low pH and nature of the parent material as reported by Prasad and Sahi (1989) [8].

453.61 ha (77.38 %) area in Khanapur micro-watershed had shown sufficient range of DTPA extractable copper while, 22.62 percent area of TGA was accounting under deficient range according to the critical limit of Cu (0.2 mg kg^{-1}) suggested by Lindsay and Norvell (1978) [4]. Raghupathi (1989) reported that DTPA extractable copper content in North Karnataka soils was in sufficient range of > 0.2 to 1.2 mg kg^{-1}.

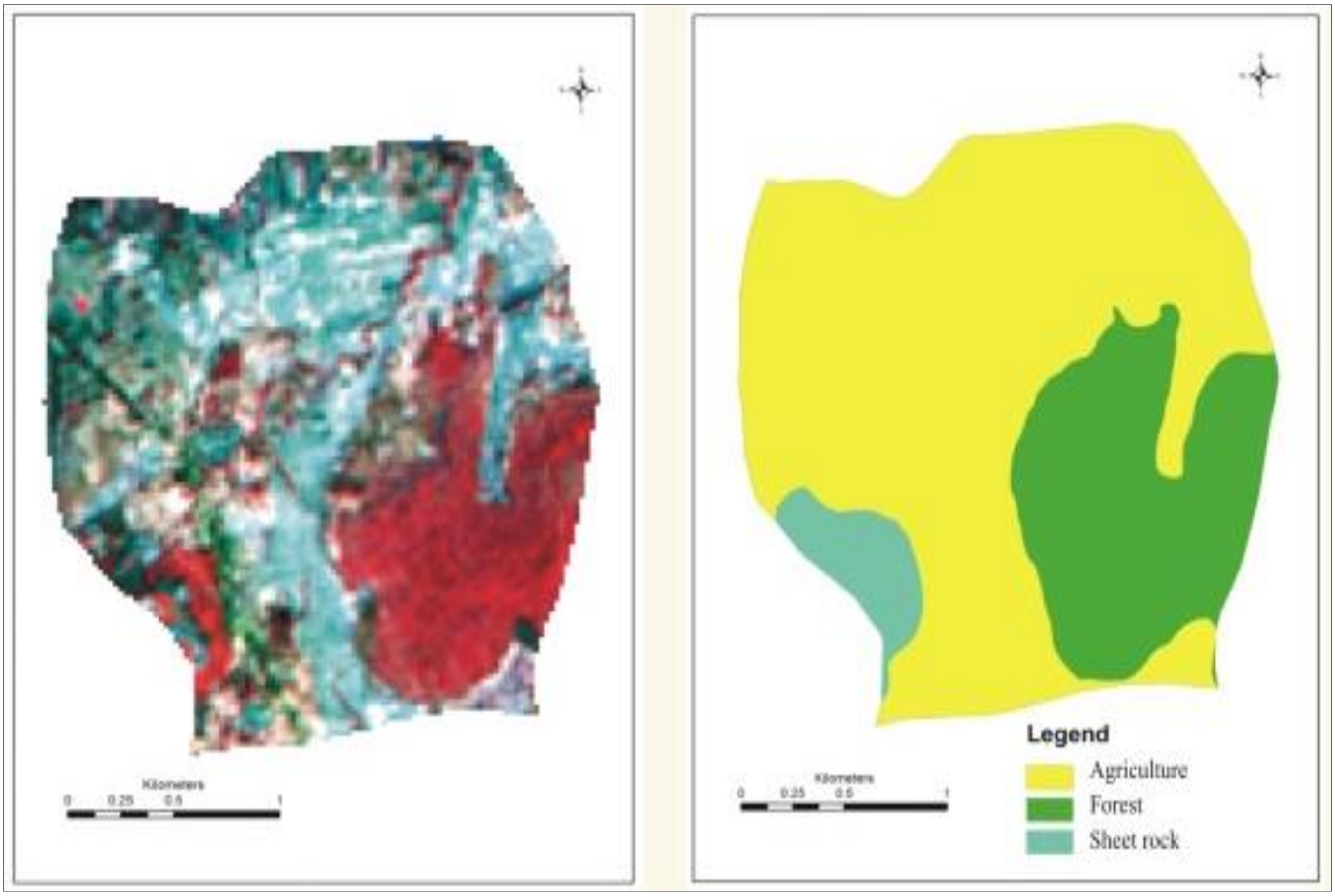
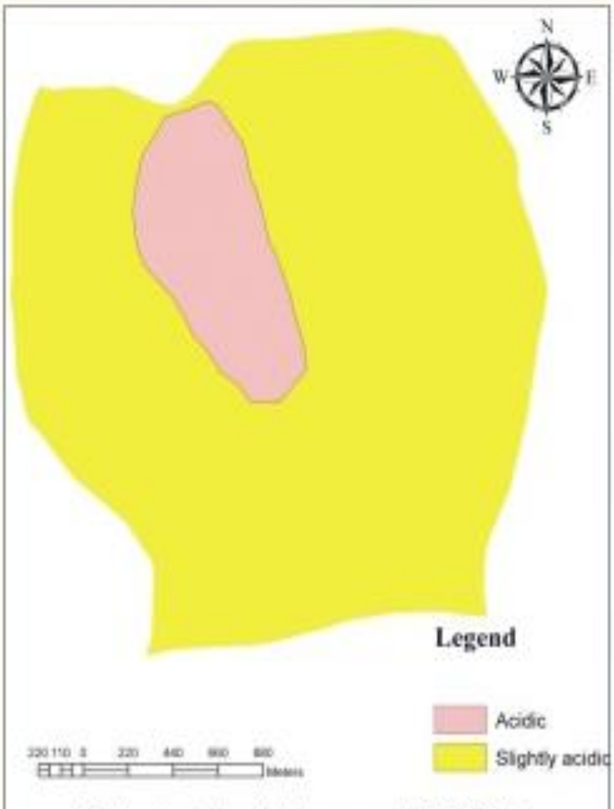
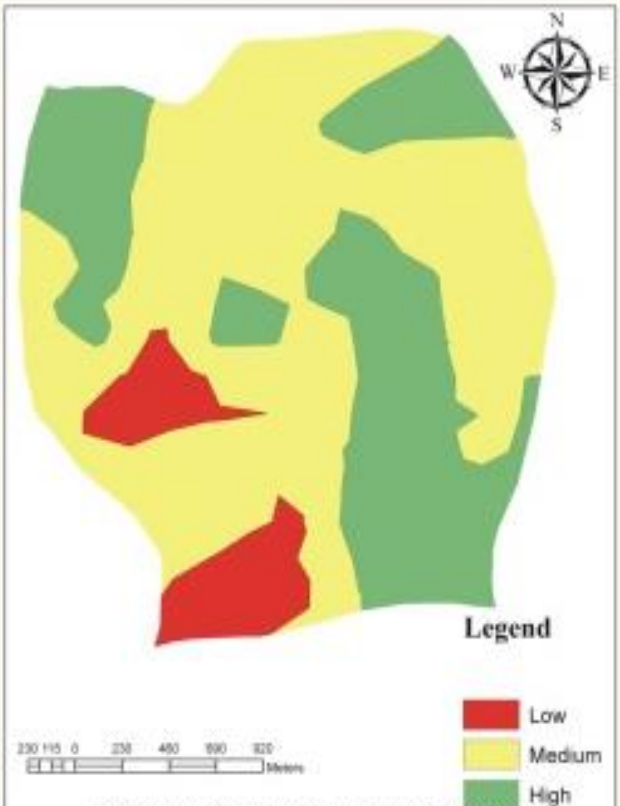


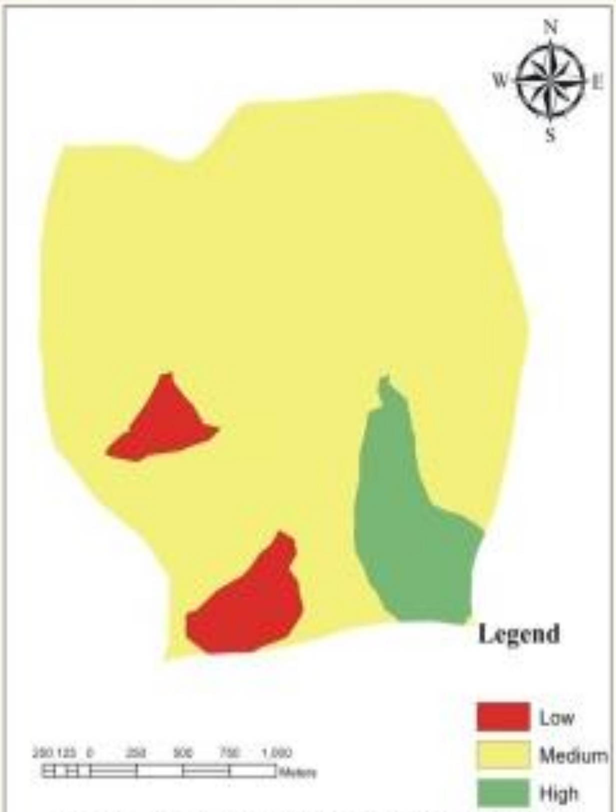
Fig 1: LISS III image and land use/land cover map of Khanapur micro-watershed



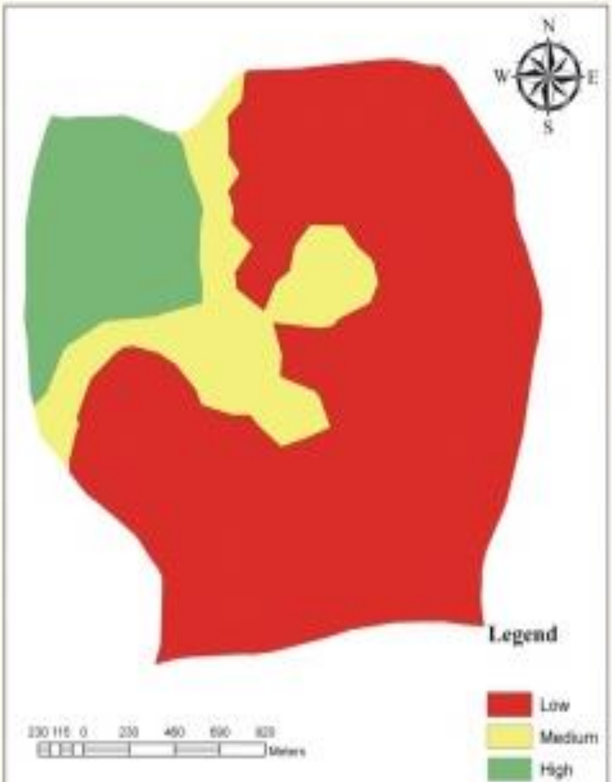
Soil pH status of khanapur (4D7C9L1c) micro watershed



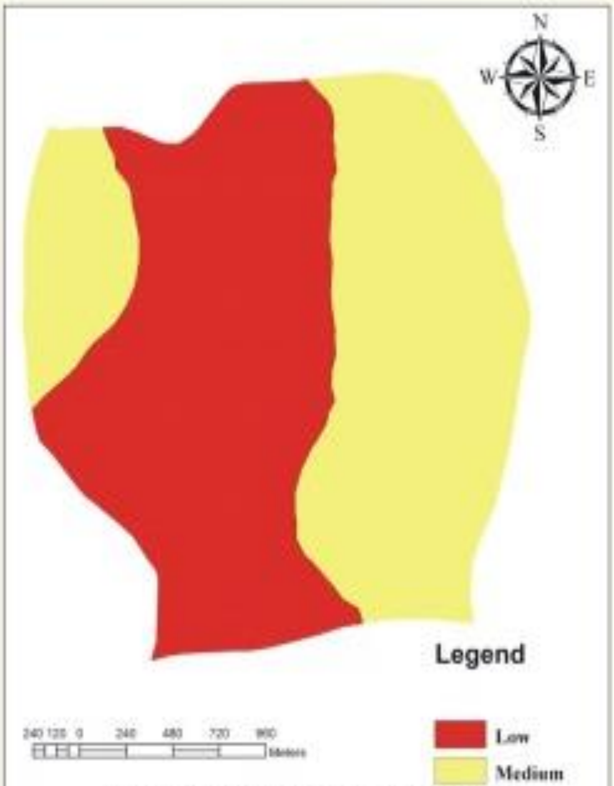
Soil organic carbon status of khanapur (4D7C9L1c) micro watershed



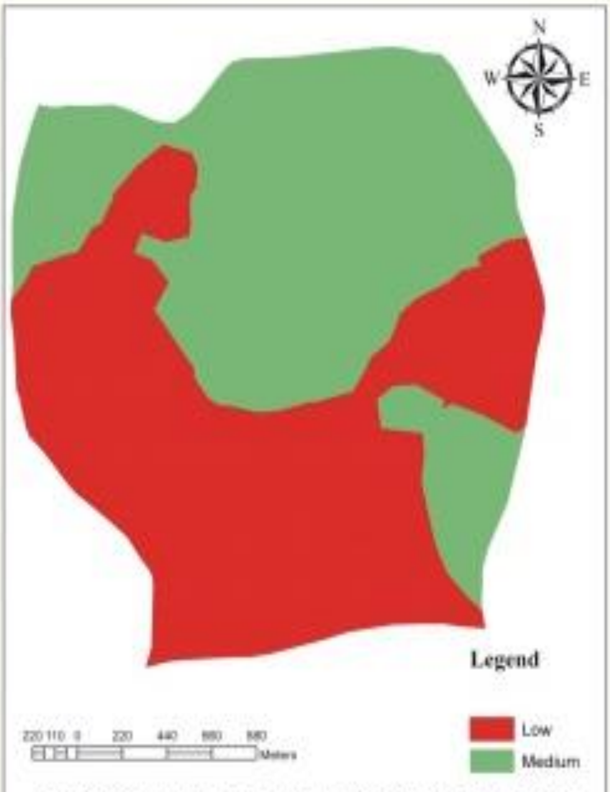
Available nitrogen status of soils of khanapur (4D7C9L1c) micro watershed



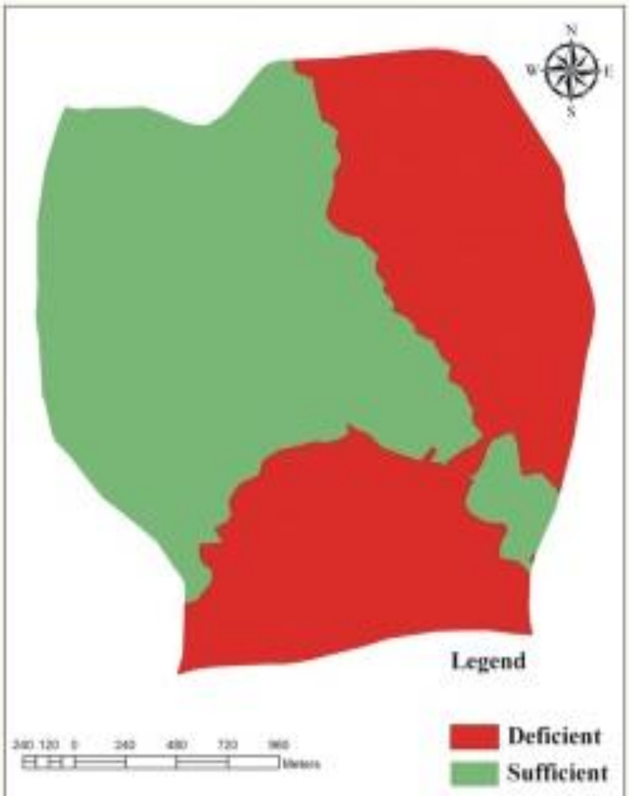
Available P_2O_5 status of soils of khanapur (4D7C9L1c) micro watershed



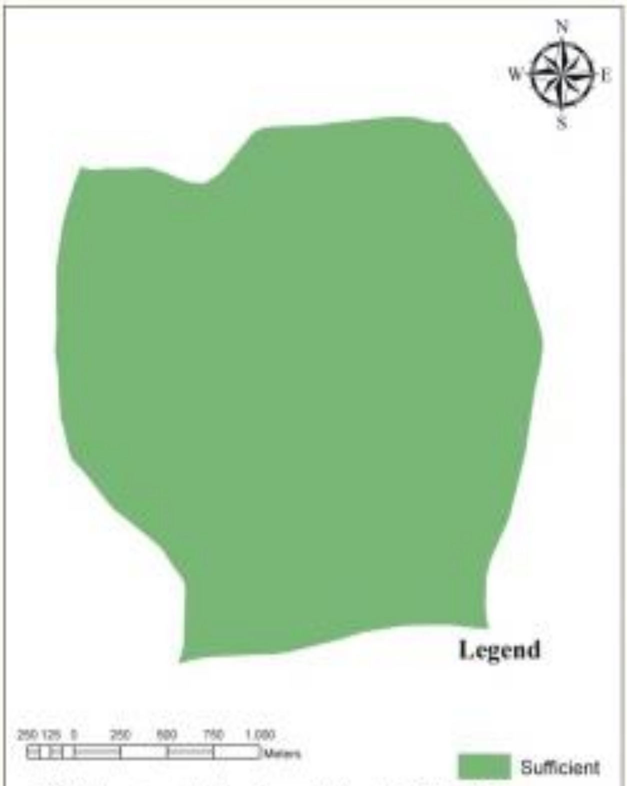
Available K_2O status of soils of khanapur (4D7C9L1c) micro watershed



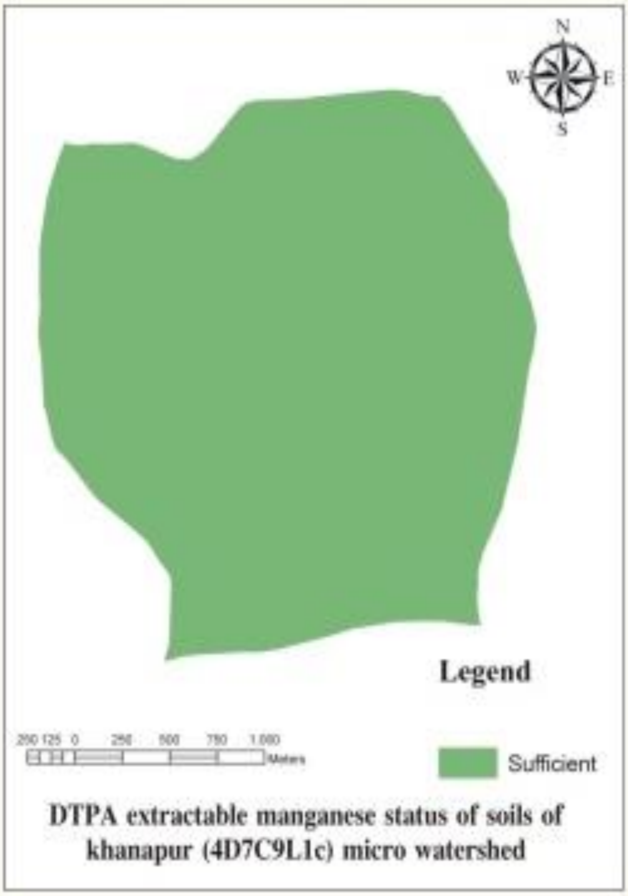
Available sulphur status of soils of khanapur (4D7C9L1c) micro watershed



DTPA extractable zinc status of soils of khanapur (4D7C9L1c) micro watershed



DTPA extractable iron status of soils of khanapur (4D7C9L1c) micro watershed



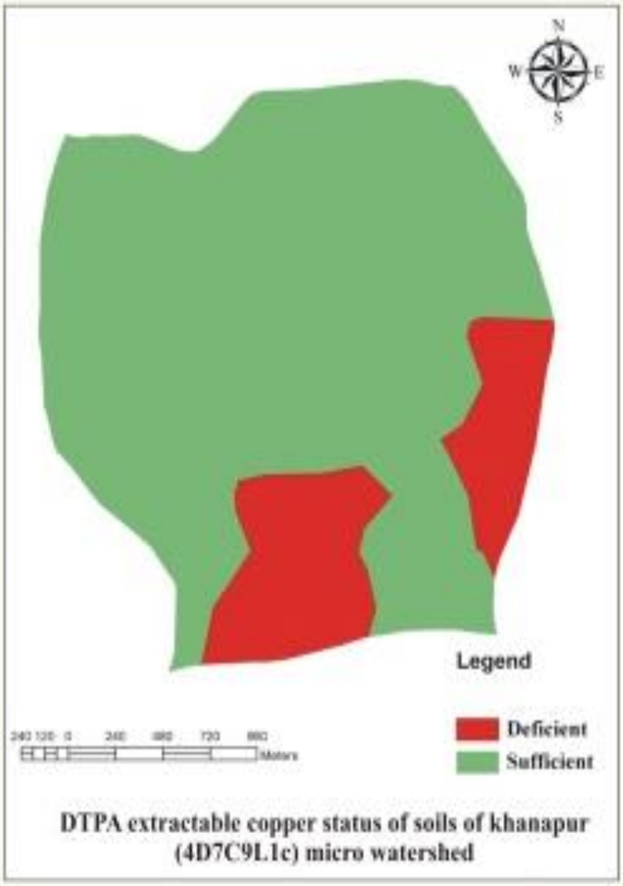


Table 1: Area under broad land use classes in the Khanapur micro-watershed of Belgaum district

Land use class	Area (ha)	% of TGA
Agricultural land	406.47	69.34
Forest land	151.20	25.79
Sheet rock	28.57	4.87
Total geographical area	586.24	100.00

Table 2: Chemical and nutrient quality parameters of soils in selected micro-watershed

Soil parameter	Khanapur		
	Mean	SD	Range
pH (1:2)	5.85	0.44	4.98-6.99
EC (1:2) dS m^{-1}	0.09	0.04	0.04-0.21
Organic carbon (g kg^{-1})	6.9	2.7	3.0-12.9
Available nitrogen (kg ha^{-1})	412	161	180-769
Available P_2O_5 (kg ha^{-1})	25	31	5-112
Available K_2O (kg ha^{-1})	178	75	70-335
Available sulphur (mg kg^{-1})	9.87	4.24	2.37-19.98
Exch. calcium (cmol (p+) kg^{-1})	3.07	2.53	0.62-11.25
Exch. magnesium (cmol (p+) kg^{-1})	0.81	0.59	0.11-2.49
DTPA extractable zinc (mg kg^{-1})	0.73	0.33	0.1-1.38
DTPA extractable iron (mg kg^{-1})	15.24	3.89	3.50-20.9
DTPA extractable manganese (mg kg^{-1})	11.37	4.91	2.1-21.30
DTPA extractable copper (mg kg^{-1})	0.49	0.44	0.02-1.49

Table 3: Chemical and nutrient quality parameters of soils under agricultural and forest land in Khanapur micro-watershed

Soil parameter	Agricultural land			Forest land		
	Mean	SD	Range	Mean	SD	Range
pH (1:2)	6.11	0.37	5.29-6.99	5.76	0.44	4.98-6.82
EC (1:2) dS m^{-1}	0.10	0.04	0.04-0.21	0.08	0.03	0.05-0.15
Organic carbon (g kg^{-1})	6.6	2.6	3.0-11.7	8.0	2.9	4.9-12.9
Available nitrogen (kg ha^{-1})	390	153	180-698	475	175	292-769
Available P_2O_5 (kg ha^{-1})	34	26	5-112	8	6	5-33
Available K_2O (kg ha^{-1})	173	73	79-335	202	76	100-322
Available sulphur (mg kg^{-1})	8.74	3.36	2.68-14.92	10.53	4.57	2.37-19.98
Exch. calcium (cmol (p+) kg^{-1})	3.44	2.82	0.62-11.25	2.37	1.79	0.65-5.29
Exch. magnesium (cmol (p+) kg^{-1})	0.88	0.64	0.11-2.49	0.64	0.43	0.12-1.26
DTPA extractable zinc (mg kg^{-1})	0.76	0.34	0.10-1.38	0.68	0.32	0.26-1.30
DTPA extractable iron (mg kg^{-1})	15.59	4.15	3.50-20.80	13.71	2.70	10.60-20.20
DTPA extractable manganese (mg kg^{-1})	10.59	4.92	2.10-21.30	13.84	4.22	4.10-20.60
DTPA extractable copper (mg kg^{-1})	0.60	0.48	0.04-1.49	0.22	0.16	0.02-0.65

Table 4: Spatial distribution of soil fertility in the selected micro-watersheds

Soil parameter	Category	Limits	Khanapur (586.24 ha)	
			Area (ha)	% of TGA
pH (1:2)	Acidic	<5.5	41.43	7.07
	Slightly acidic	5.5-6.5	544.81	92.93
	Neutral	6.5-7.5		
	Slightly Alkaline	7.5-8.5		
	Alkaline	>8.5		
Organic carbon (g kg^{-1})	Low	< 5	46.12	7.87
	Medium	5-7.5	152.13	25.95
	High	>7.5	387.99	66.18
Available nitrogen (kg ha^{-1})	Low	<280	48.36	8.25
	Medium	280-560	475.91	81.18
	High	>560	61.97	10.57
Available P_2O_5 (kg ha^{-1})	Low	<22.5	420.19	71.68
	Medium	22.5-55	83.90	14.31
	High	>55	82.15	14.01
Available K_2O (kg ha^{-1})	Low	<180	291.79	49.77
	Medium	180-360	294.45	50.23
	High	>360		
Available sulphur (mg kg^{-1})	Low	<10	289.82	49.44
	Medium	10-20	296.42	50.56
DTPA extractable zinc (mg kg^{-1})	Deficient	<0.6	311.94	53.21
	Sufficient	>0.6	274.30	46.79
DTPA extractable iron (mg kg^{-1})	Deficient	<4.5		
	Sufficient	>4.5	586.24	100.00
DTPA extractable manganese (mg kg^{-1})	Sufficient	>1.0	586.24	100.00
DTPA extractable copper (mg kg^{-1})	Deficient	<0.2 ppm	132.63	22.62
	Sufficient	>0.2	453.61	77.38

*TGA – Total geographic area

References

1. Doran JW, Smith MS. Organic matter management and utilization of soil and fertilizer nutrients in Mortuedt *et al* Soil fertilizer and Organic Matter in different components of production system. SSSA Special Publication 19 Maidison USA, 1987, 396.
2. Ettema CH, Wardle DA. Spatial soil ecology. Trends in Ecology and Evolution. 2002;174:177-183.
3. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt Ltd New Delhi; c1973.
4. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc iron manganese and copper. Soil Science Society of America Journal. 1978;42:421-428.
5. Moritsuka N, Yanai J, Umeda M, Kosaki T. Spatial relationships among different forms of soil nutrients in a paddy field. Soil Science Plant Nutrition. 2004;504:565-573.
6. Muhr GR, Datta NP, Shankara SN, Dever F, Lecy VK, Donahue RR. Soil testing in India. USAID mission to India; c1963.
7. Prasad SN, Sahi BP. Distribution of Manganese in relation to soil properties in some typical soil profiles. Journal of the Indian Society of Soil Science. 1989;37:567-570.
8. Prasad SN, Sakal R. Availability of iron in calcareous soils in relation to soil properties. Journal of the Indian Society of Soil Science. 1991;39:658-661.
9. Raghupathi HB. Investigation on soil copper and crop response in selected soils of Karnataka. MSc Agri Thesis University of Agricultural Sciences Dharwad; c1989.
10. Sarkar DU, Baruah Gangopadhyay SK, Sahoo AK, Velayuthum M. Characteristics and classification of soils of Loktak catchment area of Manipur for sustainable land use planning. Journal of the Indian Society of Soil

Science. 2002;50:196-204.
11. Seybold CA, Herrick JE, Brejda JJ. Soil resilience a fundamental component of soil quality. Soil Science. 1999;164:224-234.
12. Singh G, Ganeshmurthy AN. Influence of changing land use on the micronutrient status of middle Andamans. Journal of the Indian Society of Soil Science. 1991;39:363-364.
13. Singh G, Ganeshmurthy AN, Singh NT. Influence of changing land use on some properties of tropical rainforest soils of Andaman. In Proc National Seminar on micronutrient in soils and crops PAU Ludhiana; c1987.
14. Sojka RE, Upchurch DR. Reservations regarding the soil quality concept. Soil Science Society of America Journal. 1999;63:1039-1054.
15. Venkataratnam L, Manchanda ML. Remote sensing in soil resource management. ISPRS Workshop on Application of Remote Sensing and GIS for Sustainable Development National Remote Sensing Agency Hyderabad. 1997 Nov, 24-25.
16. Kumar VT, Reddy SM, Krishna GV. Characteristics and Classification of soils of high rainfall zone of Andhra Pradesh. Agropedology. 1994;4:31-43.