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Soil Fertility Mapping of Major Nutrients in Hosahalli Village Tank Command Area, Hassan District using Geographical Information System (GIS)

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Abstract

The purpose of a soil nutrient inventory is to raise understanding of the soil's potential and limits so that it can be used effectively. Higher yields can be achieved by judicious use of fertilizer in the appropriate amounts. The present study was undertaken to assess the soil fertility status for fertilizer recommendation mapping of paddy in the command area of Hosahalli village tank, Hassan. Fifty-nine composite soil samples were collected covering an agricultural area of 23.94 ha at 40 m grid intervals and analysed for soil reaction, salinity, organic carbon, major and secondary nutrients at laboratory using standard methods. Using Arc-GIS the data generated was processed and mapped. Kriging and inverse distance weighting interpolation method was followed. A raster map was developed using the grid points merged with analysed data and then vector spatial soil fertility maps were generated using Arc-GIS. Fertilizer recommendations based on soil tests help to improve soil fertility and crop output with less fertilizer use.

Keywords: Fertility status, Command area, Kriging, Arc-GIS, Fertilizer recommendations

Excessive population expansion in the current twenty-first century has led farmers to cultivate high-yielding cultivars intensively in order to increase food supply, but this has resulted in a significant reduction in soil fertility status in Indian soils. Soil and water are essential for life, and haphazard management of natural resources has resulted in resource deterioration, causing grave worry among planners, researchers, the general public, and farmers. Soil and water require scientific management and conservation in compliance with environmental regulations in order to ensure the system's long-term production. Soil resource inventory raises understanding of soil's potential and limitations, allowing for more effective use. These insight data on soil can be employed for soil and land resources management and development (Manchanda *et al.*, 2002). In the current situation, comprehensive mapping of available soil nutrients is required for site-specific nutrient management via soil fertility maps. Digital maps are precise and effective tools for visually connecting a feature to any given geographic location. Precision management tools such as the global positioning system (GPS) and geographic information system (GIS) are the most essential techniques. GIS analyses and displays several data layers derived from diverse sources and it is particularly useful in soil surveys for managing enormous data generated using conventional and remote sensing technology in both spatial and non-spatial formats (Zhang *et al*., 2010). GPS helps in knowing accurate point of soil fertility variation.

Higher yields can be achieved by judicious use of fertilisers in the appropriate amounts. It is critical to obtain knowledge on the appropriate fertiliser dose based on soil test values for various soils. As a result, the use of soil testing as an analytical tool for fertiliser adjustment and advice is becoming more important. The overall amount of nutrients administered to a given area and crop is reduced when fertiliser is applied based on soil tests. The present study was conducted with the objective of preparing thematic maps of soil nutrient status in command area of Hosahalli village tank of Hassan district.

Material and Methods

The command area of Hosahalli village tank is located in Alur taluk of Hassan district with an extent of 23.94 ha. The command area of Hosahalli village tank is situated at 12° 55' 40.75" to 12° 56' 19.12" North latitude and 75° 56' 56.40" to 75° 55' 45.72" East longitude. The Hosahalli village tank comes under Southern Transition Zone (Zone VII) of Karnataka. The soils in the command area are majorly belong to order *Alfisols*, which represents one of the more important soil orders for food and fiber production. The soil texture varies from loamy sand to clay. The altitude of command area is 953 m above mean sea level. The climate is hot, moist, sub-humid and the annual rainfall ranges from 612 mm to 1054 mm. More than 60 per cent of the rain is received by southwest monsoon in the *kharif* season. Location map of the study area has been shown in Fig. 1.

A tracing film was overlaid on the toposheet covering the study area. Boundary of the command area and important land features like roads, river, tanks *etc*. were extracted. Thus, a map having the above common land features was used as a base map for preparing different the matic maps. Study area was delineated with the help of topographic maps and watershed atlas which was prepared by Karnataka State Remote Sensing Application Centre, Bangalore.

The demarcation of the study area was done at 1:50,000 scale toposheet and 1:5000 scale the base map with

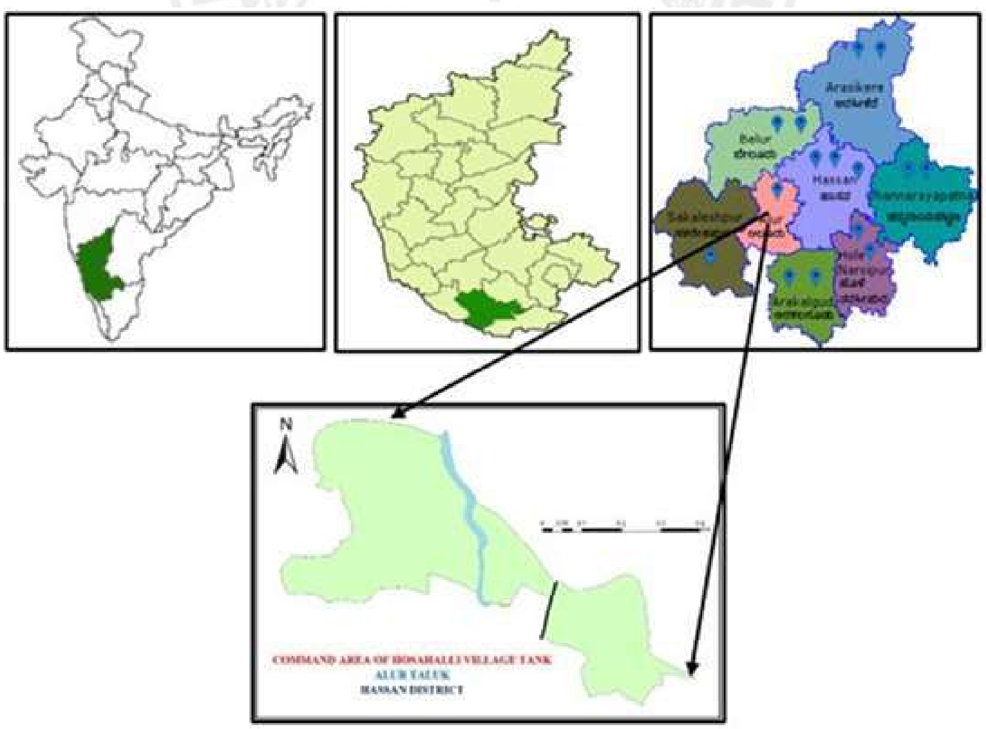

Fig. 1 : Location map of command area of Hosahalli village tank

Cartosat-1 PAN 2.5 m and resources at-2 LISS-IV MX-merged satellite imagery was used for soil survey. Fifty-nine soil samples were collected at 40 m grid spacing (Fig. 2). Later soil samples were analysed for soil chemical properties and nutrient content by using standard procedures.

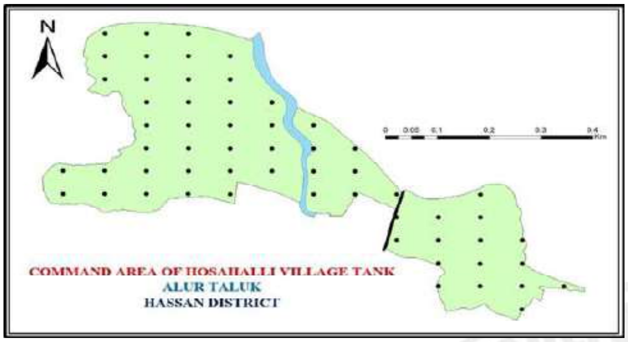

Fig. 2 : Grid points of sample collection in command area of Hosahalli village tank

The soil samples were air dried under shade, powdered using pestle and mortar and passed through 2 mm sieve. Later soil samples were analysed for soil reaction, electrical conductivity, organic carbon, major and secondary nutrients at laboratory using standard methods.

Results and Discussion

The nutrient status data acquired from the fifty-nine soil samples was utilised to create fertility maps for the research area using Arc-GIS software. The information obtained was used to create a soil fertility data base using Arc-GIS software. Soil spatial variability maps were created by interpolating point data based on soil test readings. Initially, Arc-GIS software was used to map the soil test values for all parameters such as pH, EC, available N, available P_2O_5 and available K_2O. The results of soil tests were divided into different categories like, low, medium, and high. The point data was then interpolated in order to generate a continuous surface in the map. For mapping soil test values, ordinary kriging was utilised as an interpolation tool. Soil fertility maps are shown in Fig. 3.

The soil pH of the command area of Hosahalli village tank fall under acidic condition with pH value of soils varied from 4.20 to 5.80 with a mean value of 4.84, standard deviation of 0.43 and CV of 8.94 per cent (Table 1). The complete study area (23.94 ha) comes under acidic (<6.5) which was due to continuous paddy cultivation over the years (Table 2). The variation in soil reaction was associated with parent material, rainfall and topography (Thangasamy *et al*., 2005). Continuous cultivation of paddy in standing water and high rainfall led to leaching of basic ions like Ca^{2+}, Mg^{2+} and K^{+}. Similar results were reported by Singh *et al*., 2014.

Electrical conductivity (EC) of the soils in the study area ranged from 0.036 - 0.474 dS m^{-1} with a mean value of 0.155 and standard deviation of 0.094 with CV of 60.48 per cent (Table 1). The complete study area (23.94 ha) comes under normal (< 0.8 dS m^{-1}) salinity class (Table 2). Good natural drainage system led to leaching of salts in to lower horizons made study area soil free from salinity problem. The outcomes are in accordance with the findings of Kumar (2011), Shivasankaran *et al*. (1993) and Sharma *et al*. (2008).

Table 1

Descriptive statistical analysis of spatial variability of soil properties of command area of Hosahalli village tank

Soil properties	Range	Mean	SD	CV (%)
pH	4.20 - 5.80	4.84	0.43	8.94
EC (dS m^{-1})	0.036 - 0.474	0.155	0.094	60.48
OC (%)	0.33 - 1.02	0.56	0.18	33.03
Available N (kg ha^{-1})	175.62 - 765.18	369.73	98.40	26.61
Available P (kg ha^{-1})	1.15 - 43.09	9.25	7.85	84.85
Available K (kg ha^{-1})	41.53 - 897.36	265.59	127.23	47.90

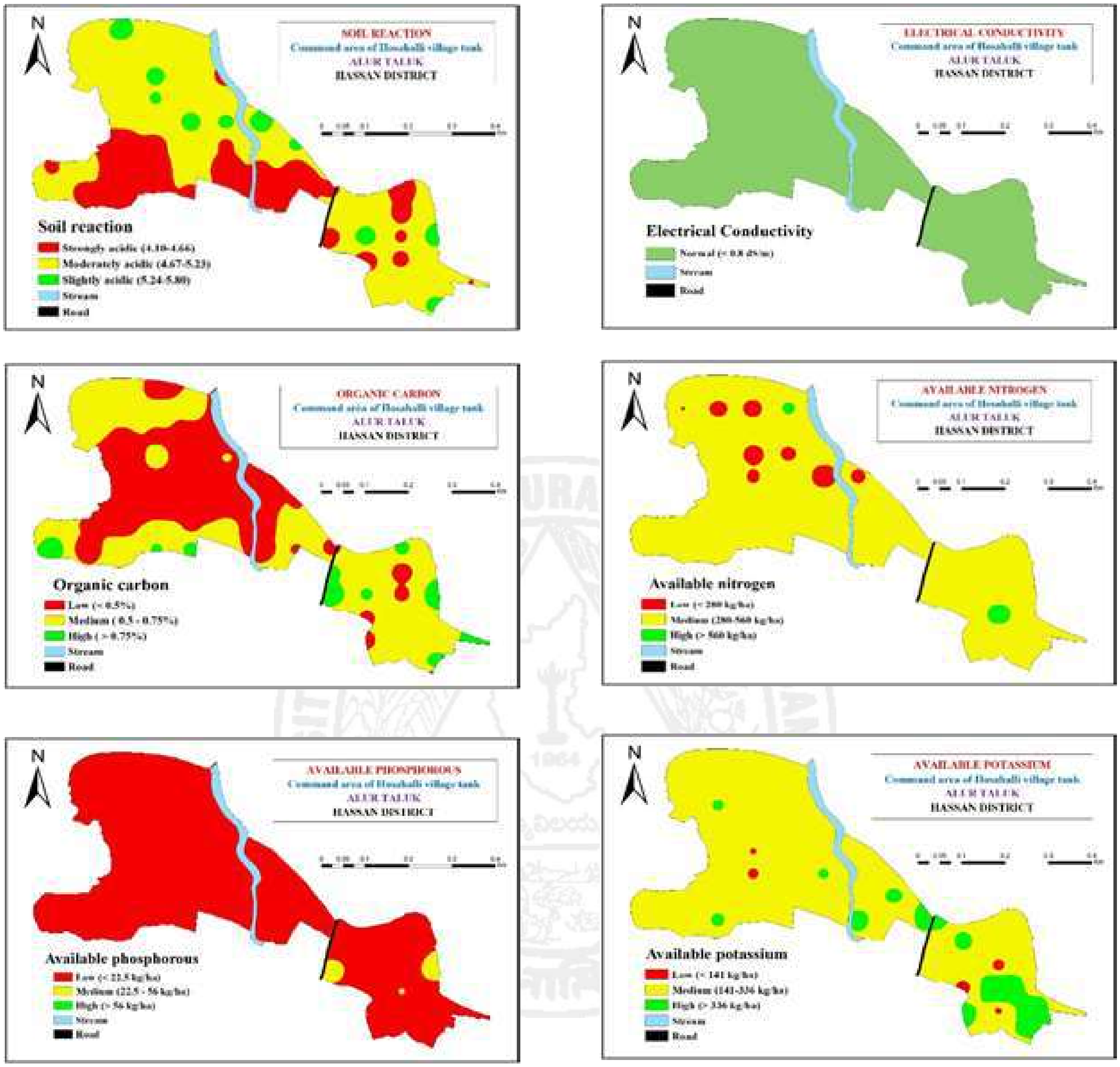

Fig. 3 : Fertility status maps of command area of Hosahalli village tank

The organic carbon (OC) (%) ranged from 0.33 to 1.02 per cent with mean of 0.56 per cent and standard deviation of 0.18 with CV of 33.03 per cent (Table 1). Majority of soils in command area are low in OC content. About 4.06 ha (16.94 %) of the command area recorded high organic carbon content (>0.75 %) due to continuous application of organic manures in the past and litter fall from nearby trees, 12.19 ha (50.84 %) of paddy fields recorded low OC content (< 0.5 %) and in remaining 7.72 ha (32.20 %) area, the OC content varied from medium to high OC content (0.5 to 0.75 %) (Table 2).

The available N content of command area ranges from 175.62 to 765.18 kg ha^{-1}, with mean value of 369.73 kg ha^{-1} and SD of 98.40 with CV of 26.61 per cent (Table 1). The major area of command area *i.e.*, 19.91 ha (83.05 %) was under medium available nitrogen range, the low available nitrogen range in 3.25 ha (13.55 %) and only 0.81 ha (3.38 %) was under high available nitrogen range (Table 3).

TABLE 2

Status of soil chemical properties of command area of Hosahalli village tank

Soil properties	Command area of Hosahalli village tank	
	Area (ha)	Area (%)
Soil reaction (pH)		
Acidic (<6.5)	59	100
Electrical conductivity (EC)		
Normal (< 0.8 dS m^{-1})	23.94	100
Organic carbon (OC)		
Low (<0.5 %)	12.19	50.84
Medium (0.5 - 0.75 %)	7.72	32.20
High (>0.75 %)	4.06	16.94

Soil available phosphorus status varied from 1.15 to 43.09 kg ha^{-1}, with mean value of 9.25 kg ha^{-1} and standard deviation of 7.85 with CV of 84.85 per cent (Table 1). The 22.76 ha (94.91 %) was low in available phosphorus in low lying paddy area and 1.21 ha (05.09 %) area was medium in available phosphorus range status (Table 3). In command area of Hosahalli village tank most of the soils were low in available phosphorus. This could be attributed to the fixation of released phosphorus by clay minerals and oxides of iron and aluminium (Vijay Kumar *et al*., 1994). The present findings were in line with those of Ravikumar (2009).

Soil available potassium status in soils of command area of Hosahalli village tank ranged from 41.53 to 897.36 kg ha^{-1}, with mean value of 265.59 kg ha^{-1} with standard deviation of 127.23 and CV of 47.90 per cent (Table 1). In the command area 4.87 ha (20.33 %) was in low,17.07 ha (71.18 %) area was in medium and 2.03 ha (8.47 %) of the command area was under high available potassium range (Table 3). The command area soils were majorly under medium to high potash content. Adequate (medium to high) available K in these soils may be attributed to the presence of K-rich minerals like illite and feldspars. Soils rich in vermiculite and micas can have large amounts of non-exchangeable potassium and this large reserve of non-exchangeable cannot be used by the current crop (Pal, 1985 and Ravikumar, 2009).

TABLE 3

Status of major nutrients of command area of Hosahalli village tank

Soil properties	Command area of Hosahalli village tank	
	Area (ha)	Area (%)
Available nitrogen		
Low (< 280 kg ha-1)	3.25	13.55
Medium (280-560 kg ha-1)	19.91	83.05
High (>560 kg ha-1)	0.81	03.38
Available phosphorous		
Low (< 22.9 kg ha-1)	22.76	94.91
Medium (22.9-56.3 kg ha-1)	1.21	05.09
Available potassium		
Low (< 141 kg ha-1)	2.03	08.47
Medium (140-336 kg ha-1)	17.07	71.18
High (> 336 kg ha-1)	4.87	20.33

The highest variation was found with available phosphorous (84.85 %) in the study area followed by electrical conductivity (60.48 %) and lowest variation was found with soil reaction (8.94 %) followed by available nitrogen (26.61 %) (Table 2). The results were in similarity with the findings of Singh *et al*. (1993), Courtin *et al*. (1983), Ameyan (1986) and Gupta *et al*. (1999).

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