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SOIL MACRO NUTRIENT STATUS OF HALE HONNATTHI SUB-WATERSHED OF NORTHERN TRANSITION ZONE OF KARNATAKA, INDIA USING REMOTE SENSING AND GIS

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ABSTRACT

An investigation was carried out to assess the macronutrient status and spatial variability of surface soils (0-20 cm) in the Hale Honnatthi sub-watershed. A detailed soil survey was conducted using high-resolution WorldView-2 satellite imagery (50 cm spatial resolution), and 243 surface soil samples were collected and analyzed for soil reaction (pH), electrical conductivity (EC), organic carbon (OC), and available nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). Spatial distribution and fertility maps were generated using kriging interpolation in ArcGIS 10.8.2 at a scale of 1:7,920. The soils exhibited a wide range of pH from 5.26 to 9.04, with a mean of 7.64, indicating predominantly neutral to alkaline conditions, while EC values of 0.02–0.72 dS m⁻¹ indicated a predominantly non-saline soil environment. Organic carbon ranged from 0.08 to 1.38 per cent, with medium and high status occupying 22.55 and 42.21 per cent of the area, respectively. Available N ranged from 43.57 to 497.09 kg ha⁻¹, with 64.75 per cent of the area categorized as low. Available P and K varied from 5.73–125.95 and 25.44–862.20 kg ha⁻¹, respectively, with medium P and K status covering 54.23 and 60.98 per cent of the area. Available S showed predominantly medium status, covering 64.43 per cent of the sub-watershed. The spatial fertility assessment provides a useful basis for identifying nutrient-deficient areas and developing site-specific nutrient management strategies involving balanced fertilizer and organic manure application to improve soil health and sustain crop productivity.

Key words: Remote Sensing and GIS, Higher Productivity, Soil Fertility, Soil Mapping.

Introduction

A watershed is a geo-hydrological unit area that drains to a common point and is considered an appropriate physical unit for natural resource evaluation, planning and management. Although soil and water conservation were initially the primary objectives of the watershed programme that saw large public investments since its inception, its focus later shifted to people's participation, equity and livelihood security, particularly in the mid-1990s (Reddy *et al.*, 2006). Besides the common soil physico-chemical properties, soils also show a high degree of spatial variability with respect to soil nutrients, owing to both natural and anthropogenic processes (Panday *et al.*, 2018). Spatial variability causes uneven patterns in soil fertility levels, which is the reason behind the decreased

efficiency of fertilizers being applied uniformly across the field without considering the within-field variations (Behera *et al.*, 2018).

In this aspect, assessing the soil fertility status of the surface soils can well support variability rate of fertilizer applications and thereby great reductions in input costs and environmental impacts can be achieved. In developing countries like India, farmers regularly lack the resources to get their own soils tested. In these scenarios, all farmers may be better served by preparing regional soil maps that can provide the information they need to optimize their soil management. Regional soil maps can also be an important part of policy planning and provide farmers with generalized recommendations where site-specific sampling is not feasible (Liu *et al.*,

2016; Behera *et al.*, 2018).

Material and Methods

Hale Honnatthi Sub-watershed (4D4C2K) in Ranibennuru taluk, Haveri district) is located in between 14°42'–14°47' North latitudes and 75°32'–75°47' East longitudes, covering an area of about 3597.93 ha (Fig. 1)

Two hundred and forty-three (243) surface samples, which were well distributed in the study area were collected from a depth of 0 to 20 cm for assessments of soil fertility constraints. The soil samples were collected in polythene bags and transported with proper handling to the laboratory for analysis. The air-dried samples were ground with a wooden pestle and mortar and passed through 2 mm sieve to separate the coarse fragments (materials more than 2 mm). For analysis of organic carbon, some portion of the fine earth samples were further ground more finely and passed through 0.5 mm sieve. The finely ground samples were stored in separate sampling bottles and labelled as in the case of the main samples. The processed soil samples were analysed by following standard analytical techniques as detailed below:

Soil reaction (pH) was determined potentiometrically in a 1:2.5 soil-to-water suspension using a glass electrode as described by Jackson (2018). Electrical conductivity (EC) was determined in a 1:2.5 soil-to-water extract using

a conductivity bridge and expressed in dS m^{-1} (Jackson, 2018). Organic carbon content was determined in finely ground soil samples (0.5 mm) by the Walkley and Black wet oxidation method as described by Jackson (2018) and expressed in g kg^{-1} . Available nitrogen was determined by the modified alkaline permanganate method described by Subbiah and Asija (1956). Available phosphorus was determined by the Bray and Olsen methods as described by Jackson (2018), while available potassium was extracted using neutral normal ammonium acetate (pH 7.0) and estimated using a flame photometer (Jackson, 2018). Available sulphur was extracted using 0.15 per cent calcium chloride solution and determined by the turbidimetric method of Chesnin and Yien (1950) using a spectrophotometer (Spectronic 20-D) at 420 nm.

A dbf file consisting of data for X and Y coordinates with respect of sampling site location was created. A shape file (vector data) showing the outline of Hale Honnatthi sub-watershed area was created in Arc GIS 10.8.1. The dbf file was opened in the project window and in X-field, X- coordinates was selected and in Y-field, Y coordinates were selected. The Z field was used for different nutrients. Interpolation method by kriging was used and the map was reclassified based on ratings of respective nutrients.

Results and Discussion

Surface soil samples of farmers field based on grid 320×320m apart was collected. Two hundred and forty-three surface soil samples were collected and analyzed in laboratory for various parameters. By linking the soil fertility data to the grid points, soil fertility maps were generated in GIS using kriging for interpolation.

Soil reaction is an indicator of acidity, neutral and alkalinity of soil. Soil pH in the sub-watershed is ranged

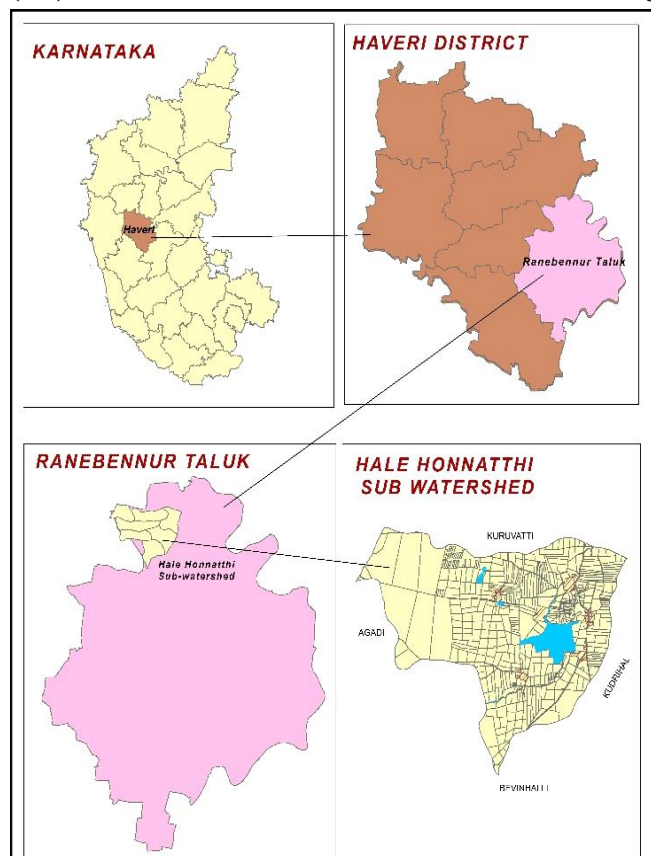


Fig. 1: Location of Hale Honnatthi sub watershed.

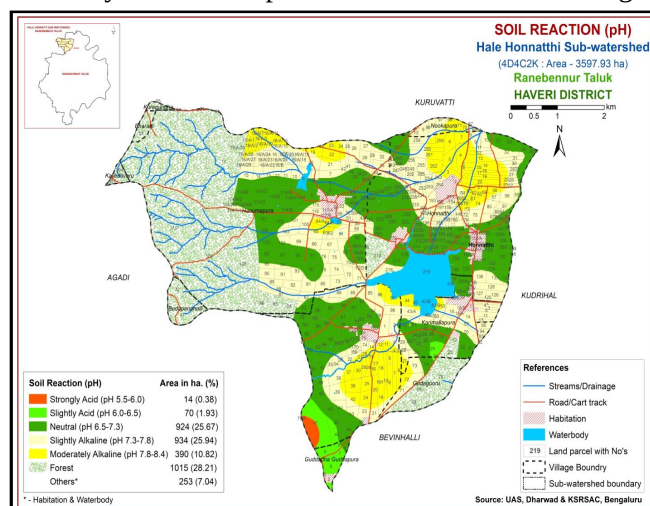


Fig. 2: Soil reaction (pH) status of Hale Honnatthi sub-watershed.

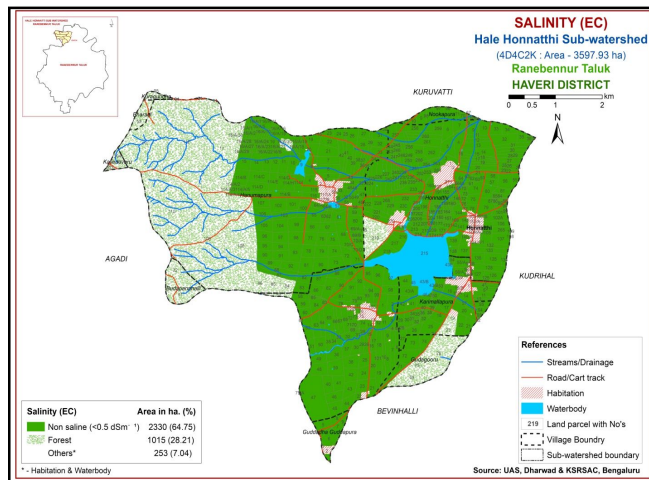


Fig. 3: Soil Electrical conductivity (EC) status of Hale Honnatthi sub-watershed.

from 5.26 to 9.04 with a mean of 7.64, S.D. of 0.82 and CV (%) of 10.79. The soils of sub-watershed were strongly acidic (pH 5.5 to 6.00) in 14 ha (0.38 %), slightly acidic (pH 6.00 to 6.50) in 70 ha (1.93%), neutral (pH 6.5-7.3) in 924 ha (25.67 %), slightly alkaline (pH 7.3 to 7.8) in 934 ha (25.94 %), moderately alkaline (pH 7.8 to 8.4) in 390 ha (10.82 %) area (Table 1 and Fig. 2). The pH varied from neutral to strongly alkaline in Huliginal micro-watershed of Bagalkot district with neutral soil predominance in micro watershed. (Nagaral *et al.*, 2026). The relatively low pH in some soils was mainly due to iron hydroxide and accumulation of higher amounts of exchangeable bases in soils which contributed to higher H^+ ion concentration. (Dasog and Patil, 2011) and variation in soil pH was related to parent material, rainfall, topography and other soil site characteristics.

Higher the EC more will be salt content in soil which affects the crop growth and development (Table 1). The electrical conductivity of soil ranged from 0.02 to 0.72

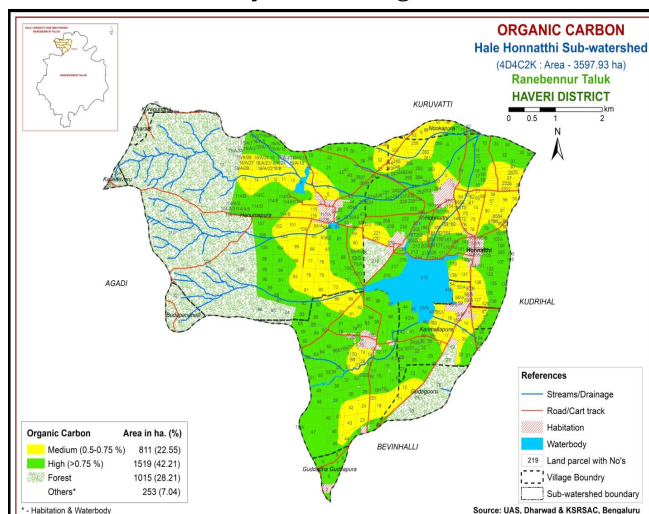


Fig. 4: Soil organic carbon status of Hale Honnatthi sub-watershed.

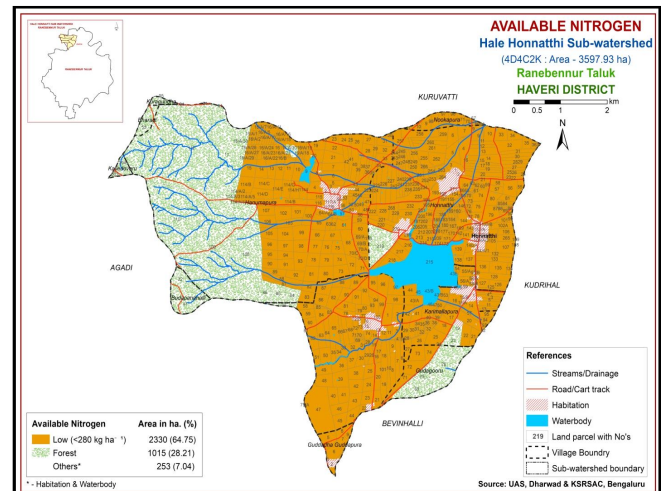


Fig. 5: Available nitrogen status of Hale Honnatthi sub-watershed.

dSm^{-1} with a mean of $0.16 dSm^{-1}$, S.D. of 0.12 and CV (%) of 77.60. The soils of sub-watershed were non saline ($< 0.5 dSm^{-1}$) with 2330 ha (64.75 %) of area, remaining 1015 ha (28.21 %) and 253 ha (7.04 %) was forest and other land use where soil samples were not analyzed. (Fig. 3). The soils of sub-watershed were in undulating nature of terrain coupled with moderate rainfall region with good drainage facility so the accumulation of soluble salts was negligible. (Gurumurthy *et al.*, 2019). Similar results were found with Ashay and Patil (2021), Jahnvi *et al.*, 2020).

Organic carbon is indication of life of soil and it account of carbon status of soil which is a basic element (Table 1). The organic carbon of soils of Hale Honnatthi sub-watershed ranged from 0.08 to 1.38 % with the mean of 0.62 %, S.D. of 0.31 and CV (%) of 51.46. The organic carbon content was medium in 811 ha (22.55 %) area and high in 1519 ha (42.21 %) area as described in Fig. 4. It is due to soils of semi-arid type of climate with high

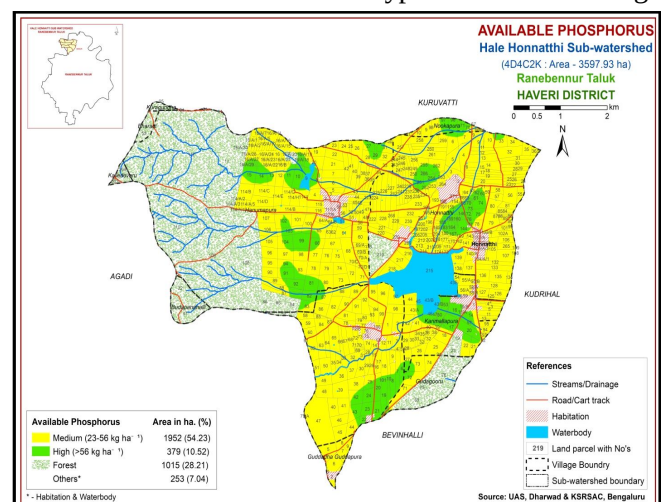


Fig. 6: Available phosphorus status of Hale Honnatthi sub-watershed.

Table 1: Soil macronutrient status of surface soils of Hale honnatti sub watershed.

Properties	Min.	Max.	Mean	Std. Dev	CV (%)
pH	5.26	9.04	7.64	0.82	10.79
EC (dS m ⁻¹)	0.02	0.72	0.16	0.12	77.60
Organic carbon (%)	0.08	1.36	0.62	0.31	51.46
Available N (kg/ha)	43.57	497.09	178.17	101.12	56.76
Available P ₂ O ₅ (kg/ha)	5.73	125.95	51.26	26.23	51.14
Available K ₂ O (kg/ha)	25.44	862.20	242.47	161.33	66.53
Available S (kg/kg)	5.00	53.75	20.62	10.88	52.75

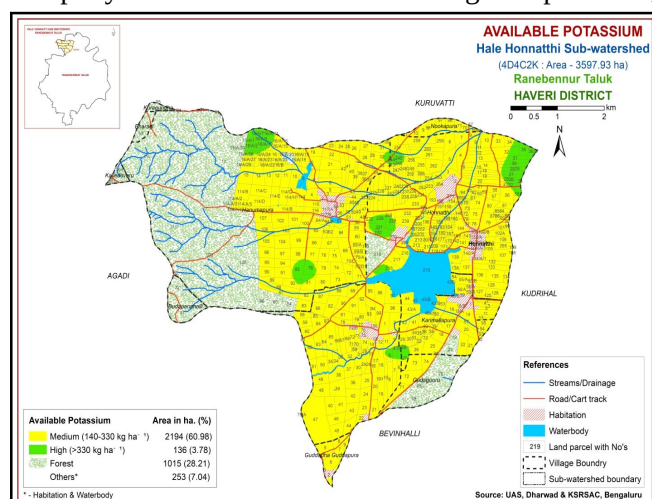
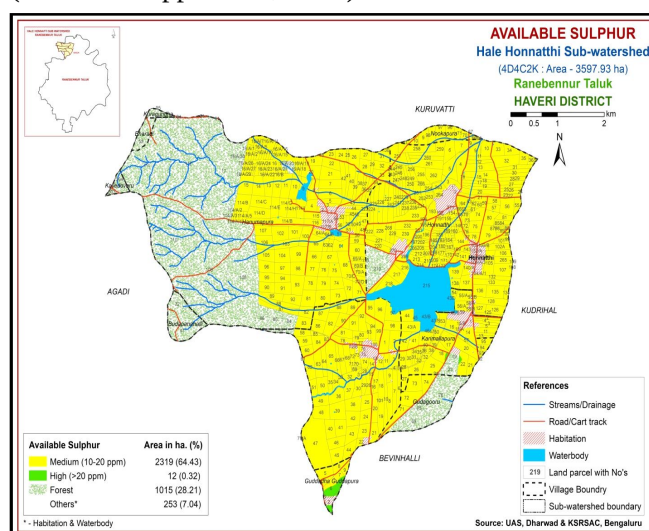
temperature prevailing in the area resulting in low to medium organic carbon status. (Patil *et al.*, 2011). The low to medium organic matter content in the soils was attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetation cover, thereby leaving less organic carbon in the soils (Sireesha and Naidu, 2013).

The nitrogen status in soil indicates the availability of nitrogen for plant uptake for growth and development of crop especially, vegetative growth of plant. The available nitrogen status of soil varied from 43.57 to 497.09 kg/ha with mean of 178.17 kg/ha, S.D. of 101.12 and CV (%) of 56.76 (Table 1). Mapping of available nitrogen status revealed that soils of sub-watershed were found to be low in 2330 ha (64.75%) area (Fig. 5). This might be due to variation in soil properties like clay content accompanied with arid environmental conditions and also due to growing of exhaustive crops like maize and cotton. The variation in N content under each soil type could be attributed to soil management; application of FYM and fertilizer to previous crop. Another possible reason could be due to high uptake of nitrogen nutrient uptake by crop. This was characteristic of tropical soils where nitrogen is rapidly mineralized and lost due to high temperatures,

leaching and poor organic inputs (Maji *et al.*, 2010).

The phosphorus status of soil indicates the availability of phosphorus for crop growth. Available phosphorus content in soil ranged from 5.73 to 125.95 kg/ha with mean of 51.26 kg/ha, S.D. of 26.23 and CV (%) of 51.14. The fertility map revealed that 1952 ha (54.23%) are was medium and 379 ha (10.52 %) was high in available phosphorus (Table 1 and Fig. 6). The few areas of sub-watershed remained low in P due to P fixation in alkaline conditions. The farmers of locality were using DAP as source of nutrients in adequate quantity. At some locations, P₂O₅ was exceptionally high may be due to heavy use of complex fertilizers. Similar results were reports by Patil *et al.*, (2011) and Ravikumar *et al.*, (2009). The low to medium availability of P in the soils of the study area might be the result of past fertilization, pH, organic matter content, texture, various soil management and agronomic practices (Patil *et al.*, 2017).

Potassium not only improves plant quality but also contributes to the development of disease resistance in plants. The available potassium content in soils varied from 25.44 to 862.20 kg/ha with a mean of 242.47, S.D. of 161.33 and CV (%) of 66.53. From the fertility maps it is observed that 2194 ha (60.98 %) was medium and 136 ha (3.78 %) was high (Table 1 and Fig. 7). The higher content of available potassium content of soils predominance of potash rich micaceous and feldspar minerals in parent rocks (Dasog and Patil, 2011 and Pulakeshi *et al.*, 2014). Despite this, there was a strong chance that the nutrient levels in the soil were significantly altered as a result of the various management strategies that were used, particularly the type and quality of the fertilizers and manures that were applied to the soil (Chikkaramappa *et al.*, 2021).

**Fig. 7:** Available Potassium status of Hale Honnatti sub-watershed.**Fig. 8:** Soil available sulphur status of Hale Honnatti sub-watershed.

Sulphur is the element which improves the oil content in oilseed crops and pungency in few crops. Available sulphur status of soils of Hale Honnatthi sub-watershed varied from 5.00 ppm to 5.75 ppm with 20.62 ppm, S.D. of 10.88 and CV (%) 52.75. Mapping of available sulphur content revealed that 2319 ha (64.43 %) was medium, 12 ha (0.32 %) was high (Table 1 and Fig. 8). Low and medium status of available sulphur might be due to lack of sulphur addition and continuous removal by intensive cropping system. (Thangaswamy *et al.*, 2005, Patil *et al.*, 2011 and Pulakeshi *et al.*, 2014). A medium to high level of available S in the soils of the study area may be due to the addition of S to crops through single superphosphate (SSP), which the majority of farmers are using (Balanagoudar, 1989; Lavanya *et al.*, 2019; Chikkaramappa *et al.*, 2021).

Conclusion

The soil fertility assessment of the Hale Honnatthi sub-watershed revealed considerable spatial variability in soil properties and nutrient availability. The soils were predominantly neutral to alkaline and non-saline, with medium to high organic carbon status. Available phosphorus, potassium and sulphur were generally in the medium to high range, whereas nitrogen was the major fertility constraint, with 64.75 per cent of the area showing low available N status. The observed variability was associated with differences in soil properties, parent material, topography, cropping practices and nutrient management. The GIS-based fertility maps effectively identified areas with varying nutrient status and can serve as a valuable tool for site-specific nutrient management. Balanced application of organic manures and fertilizers, particularly appropriate nitrogen management, is recommended to improve soil fertility, maintain soil health and enhance sustainable crop productivity in the sub-watershed.

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References

- Balanagoudar, A.B. (1989). Investigation on status and forms of sulphur in soils of North Karnataka. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka, India.
- Behera, S.K., Shukla A.K. and Smith J.L. (2018). Spatial distribution of surface soil acidity, electrical conductivity, soil organic carbon content and exchangeable calcium and magnesium in some cropped acid soils of India. *Land Degradation and Development*. **26**, 71–79.
- Chesnin, L. and Yien C.H. (1950). Turbidimetric determination of available sulphates. *Soil Science Society of America Journal*. **15**, 149–151.
- Chikkaramappa, T., Kadalli G.G., Veerendra Patel G.M., Prakash S.S., Rajashekarappa K.S. and Chaithra M.C. (2021). Identification of soil fertility constraints in Boranakunte-1 micro-watershed, Tumkur district, Karnataka. *Journal of the Indian Society of Soil Science*. **69(1)**, 14–20.
- D'Souza, A. and Patil P.L. (2021). Soil nutrient status of soils of Kanamadi South sub-watershed of Vijayapura district. *Chemical Science Review and Letters*. **10(38)**, 274–282.
- Dasog, G.S. and Patil P.L. (2011). Genesis and classification of black, red and lateritic soils of North Karnataka. In: Special Publication on Soil Science Research in North Karnataka, 76th Annual Convention of ISSS, Dharwad Chapter. ISSS, UAS, Dharwad. 1–10.
- Gurumurthy, K.T., Balaji Naik D., Ravikumar D., Ganapathi, Raghu A.N., Raghavendra S., Thippeshappa G.N., Sindhu H.S. and Ananthakumar Patil (2019). Evaluation of soil fertility status of macronutrients and mapping in Beguru micro watershed of Tarikere Taluk of Chikkamagaluru District, Karnataka, India. *Journal of Pharmacognosy and Phytochemistry*. **8(4)**, 2593–2597.
- Jackson, M.L. (2018). Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi.
- Katti, J., Gurumurthy K.T., Ravikumar D., Girijesh G.I. and Sridhar C.J. (2020). Fertility assessment of soils of Nandipura micro-watershed under Chikkamagaluru district, Karnataka. *International Journal of Chemical Studies*. **8(5)**, 977–984.
- Lavanya, K.R., Kadalli G., Patil S.J.T., Naveen D.V. and Channabasavegowda R. (2019). Sulphur fractionation studies in soils of long term fertilizer experiment under finger millet–maize cropping sequence. *International Journal of Current Microbiology and Applied Sciences*. **8**, 1334–1345.
- Liu Y., Wang H.F., Zhang H. and Liber K. (2016). A comprehensive support vector machine-based classification model for soil quality assessment. *Soil and Tillage Research*. **155**, 19–26.
- Maji, P.K., Binita N.K., Dasog G.S. and Patil P.L. (2010). Soil fertility mapping in Ghatprabha left bank canal command area of North Karnataka by Geographic Information System technique. *Karnataka Journal of Agricultural Sciences*. **22(1)**, 73–76.
- Nagaral, N.I., Basaraj K., Prasanna S.M., Narayana Rao K., Rajesh N.L., Satishkumar U. and Vijaya B.W. (2026). Assessing soil fertility in Huliginahal micro-watershed, Karnataka, India: a basis for site-specific recommendations. *International Journal of Plant and Soil Science*. **38(2)**, 253–270.
- Pandey, D., Ojha R.B., Chalise D., Das S. and Twanabasu B. (2018). Spatial variability of soil properties under different land use in the Dang district of Nepal. *Cogent Food &*

- Agriculture*. **5(1)**, 1–19.
- Patil, P.L., Kuligod V.B., Gundlur S.S., Jahnavi K., Nagaral I.N., Shikrashetti P., Geetanjali H.M. and Dasog G.S. (2017). Soil fertility mapping by GIS in Mevundi sub watershed under Northern Dry Zone of Karnataka for site specific recommendations. *Karnataka Journal of Agricultural Sciences*. **30(2)**, 200–205.
- Patil, S.S., Patil V.C. and Al-Gaadi K.A. (2011). Spatial variability in fertility status of surface soils. *World Applied Sciences Journal*. **14(7)**, 1020–1024.
- Pulakeshi, H.B.P., Patil P.L. and Dasog G.S. (2014). Characterization and classification of soil resources derived from chlorite schist in Northern Transition Zone of Karnataka. *Karnataka Journal of Agricultural Sciences*. **27(1)**, 14–21.
- Ravikumar, M.A., Patil P.L. and Dasog G.S. (2009). Soil resource characterization, classification and mapping of 48A distributary of Malaprabha Right Bank Command, Karnataka for land use planning. *Karnataka Journal of Agricultural Sciences*. **21(4)**, 81–88.
- Reddy, R., Hemantha Kumar U. and Mohan Rao D. (2006). Participatory watershed development and the role of project implementing agency: The experience of Andhra Pradesh. *Journal of Rural Development*. **25(3)**, 363–394.
- Sahrawat, K.L. and Burford J.R. (1982). Modification of the alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. *Soil Science*. **133(1)**, 53–57.
- Sireesha, P.V.G. and Naidu M.V.S. (2013). Studies on genesis, characterization and classification of soils in semi-arid agro-ecological region: a case study in Banaganapalle mandal of Kurnool district in Andhra Pradesh. *Journal of the Indian Society of Soil Science*. **61(3)**, 161–178.
- Thangaswamy, A., Naidu M.V.S., Ramavatharam N. and Reddy R.C. (2005). Characterization, classification and evaluation of soil resources in Shivagiri micro-watershed of Chittoor district in Andhra Pradesh for sustainable land use planning. *Journal of the Indian Society of Soil Science*. **53**, 11–21.