GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

Assessment of Spatial Distribution of Major soil Nutrients in Bhagyanagar Subwatershed, Koppal District, Karnataka using GIS Techniques

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Abstract

A study on the assessment of the spatial distribution of soil nutrients was conducted in the Bhagyanagar subwatershed of Koppal district, Karnataka using GIS techniques. A total of 592 surface soil samples (0-20 cm) were collected at 320 m grid interval and analyzed the soil properties. Selective soil properties were mapped viz., Soil Reaction (pH), Electrical Conductivity (EC), Organic Carbon (OC), Available Phosphorus (P2O5), and Available Potassium (K2O). The results of the spatial distribution of soil properties like pH show 23% and 14.34% of the area were strongly alkaline (pH 8.4-9.0), and very strongly alkaline (pH>9.0), respectively. Soils are non-saline (EC <2 dSm^{-1}), OC rated from low (<0.5%) to high (>0.75%), the maximum area was occupied medium (37.5%) and low (22.67%), and 7% was high. Available phosphorus 54.87% of the area was medium (23-57 kg ha^{-1}), and 6.74% was in low (<23 kg ha^{-1}) rated. Similarly, Available potassium 45.44% of the area was medium (145-337 kg ha^{-1}) and 20.33% in high (>337 kg ha^{-1}). Spatial distribution of soil nutrients is most important to know the status of the soil fertility and assists in adjusting the fertilizer schedules to different crops in the Watershed.

Keywords: Spatial Distribution; Soil Nutrients; Organic Carbon; Phosphorus; Potassium

Introduction

Agriculture plays a vital role in the occupation of the civilized man, whereas increasing population, increasing average income and globalization effects will increase demand for quantity, quality and nutritious food, and variety of food. Therefore, pressure on decreasing available cultivable land to produce more quantity, variety, and quality of food will keep on increasing. The topsoil has an average depth of about 15-30 cm on which plants grow and the farming activities flourish. Nowadays, it is facing serious problems due to human pressure and utilization incompatible with its capacity. Hence, it is important to keep healthy and productive soil to continue our soil to function optimally to increase agriculture production with appropriate soil amendment and crop management practices[1].

Soil fertility is one of the primary constraints to agricultural production in developing countries like India[2]. It comprises not only in the supply of nutrients but also indicates their nutrient supplying capability; moreover, fertility of the soil is subject to man's control[3]. It may be maintained by scientific crop rotations and the application of manure of fertilizers. Soil nutrient content and its availability to the plants are greatly influenced by land use and management[4,5]. The relationship between the spatial variability of soil nutrients and land use patterns is established by many researchers[5,6]. Multi-nutrient deficiencies are common due to continuous applications of major nutrients (NPK) and neglect of micro-nutrients[7–9] which affects sustainability and nutritional security. Hence, attention has to be paid to identifying the extent of the problem and suggesting corrective measures for deficiencies of nutrients in various cropping systems[10]. In this context, the present study is proposed to investigate the major soil nutrients status of Bhagyanagar sub watershed, Koppal district of Karnataka using GIS techniques to bring more informed decisions to improve soil fertility and crop productivity of this region.

Materials and Methods

Study Area

The study area Bhagyanagar subwatershed is located in the central part of Karnataka in Koppal taluk and district (Figure 1). It lies between $15^{0}15'$-15^{0} 24' North latitudes and 76^{0} 6'-76^{0} 11' East longitudes and covers an area of about 6031 ha. It is bounded by Neregalla in the north-west, Tenakanakallu in the north-east, Yathnatti in the west, Koppal in the east, Hireshindhogi in the south-west, Gondabala in the south-east.

Koppal district falls under the semiarid tract of the state and is categorized as drought-prone with a total annual rainfall of 662 mm. Of this, a maximum of 424 mm precipitation is received during the south-west monsoon period from June to September, the north-east monsoon contributes about 161 mm and prevails from October to early December and the remaining 77 mm is received during the rest of the year. The winter season is from December to February. During April and May, the temperatures reach up to 45°C and in December and January, the temperatures will go down to 16°C. Rainfall distribution. The average Potential Evapo Transpiration (PET) is 145 mm and varies from a low of 101 mm in December to 193 mm in May. The PET is always higher than precipitation in all the months except in September. Generally, the length of the crop Growing Period (LGP) is < 90 days and starts from 2^{nd} week of August to 2^{nd} week of November.

The major geology observed in the subwatershed is granite gneiss and alluvium. Granite gneisses are essentially pink to gray and are coarse to medium-grained. They consist primarily of quartz, feldspar, biotite and hornblende. The gray granite gneisses are highly weathered, fractured and fissured up to a depth of about 10 m. The thickness of the alluvium generally is limited to less than a meter, except in river valleys where it is very deep extending to tens of meters. Such soils are transported and represent paleo-black soils. The study area covers rainfed lands with major crops grown in the area are Sorghum, Maize, Bajra, Cotton, Safflower, Sunflower, Red gram, Horse gram, Onion, Mulberry, Pomegranate, Sugarcane, Bengal gram and Groundnut.

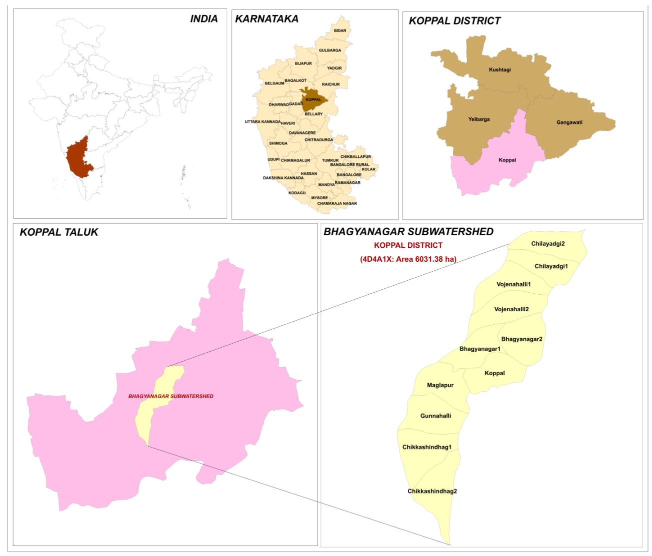

Fig. 1. Location Map of Bhagyanagar Sub-watershed, Koppal Taluk & District

Soil sampling and analysis

A total of 592 surface soil samples (0-20 cm) were collected at 320 m grid interval with the help of a global position system (GPS) during 2018. Collected soil samples were air-dried and ground to pass through a 2 mm sieve and used to determine the soil properties including major and micronutrients. Soil pH (1:2.5) and electrical conductivity (EC) were analyzed in soil water suspension as described by Jackson[11]. Organic carbon was estimated by Walkley and Black[12]. Available phosphorus was determined by Olsen et al.[13] method (pH >6.5). Available potassium by flame photometer after extraction with 1N ammonium acetate[14].

Mapping

Soils data were integrated into a GIS platform for creating and estimating nutrients spatial distribution of soil fertility and its status using kriging, which was found in the optimizer parameter tools of the geostatistical analyst extension of the Arc GIS 10.7.1 software.

Result and Discussion

Soil Reaction (pH)

Soil pH indicates soil acidity or alkalinity. A very acidic soil (pH<5.0) which contains a lower composition of nitrogen, phosphorus, calcium, and magnesium and pH with high values (>5.0) depicts the less availability of iron, manganese, copper, zinc, phosphorus, and boron. The pH value reflects the integrated effect of the acid-base reactions taking place in the soil system [15]. Spatial map of soil reaction (pH) classified into 8 classes (Table 1), pH values below 6.5 are considered as acidic, values above 7.3 are alkaline and values range between 6.5-7.3 was neutral. Slightly alkaline (pH 7.3-7.8) to moderately alkaline (pH 7.8-8.4) is distributed in the northern, southern, and western parts of the subwatershed. Maximum area in subwatershed is covered by strongly alkaline (pH 8.4-9.0) in 1394 ha (23%) followed by very strongly alkaline (pH >9.0) in 865 ha (14.34%), which distributed in the northern, western and southern part of the subwatershed as shown in (Figure 2).

Table 1. Bhagyanagar subwatershed: Soil reaction (pH) classification

Soil Reaction Classes	Total area in ha (%)
Strongly acid (pH 5.0-5.5)	9 (0.15)
Moderately acid (pH 5.5-6.0)	30 (0.5)
Slightly acid (pH 6.0-6.5)	107 (1.77)
Neutral (pH 6.5-7.3)	367 (6.09)
Slightly alkaline (pH 7.3-7.8)	503 (8.34)
Moderately alkaline (pH 7.8-8.4)	766 (12.7)
Strongly alkaline (pH 8.4-9.0)	1394 (23.11)
Very strongly alkaline (pH >9.0)	865 (14.34)

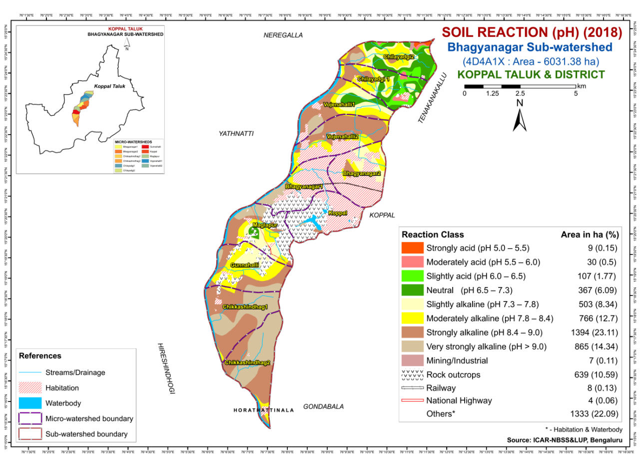

Fig. 2. Soil Reaction (pH) Map of Bhagyanagar Sub-watershed, Koppal District

Electrical Conductivity (EC)

Electrical Conductivity is a chemical property that depicts the amount of soluble salt in the soil. EC is the common measure of soil salinity and alkalinity. Table 2 and Figure 3 show the electrical conductivity of watershed is <2 dS m^{-1} and as such the soils are considered non-saline.

Table 2. Bhagyanagar subwatershed: Electrical Conductivity

Classes	Total area in ha (%)
Non saline (<2 dsm^{-1})	4041 (67)

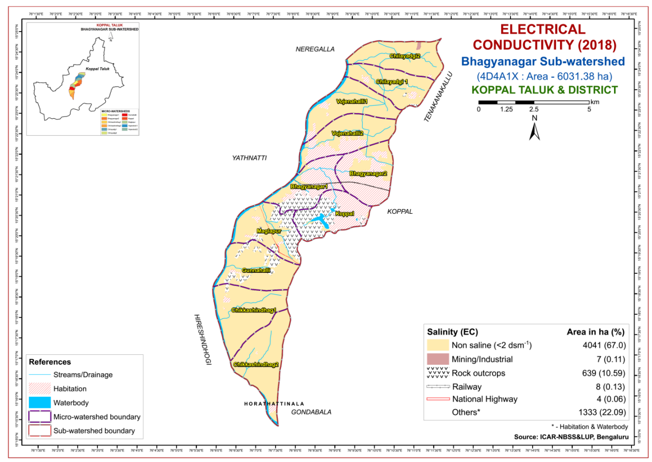

Fig. 3. Electrical Conductivity (EC) Map of Bhagyanagar Sub-watershed, Koppal District

Organic Carbon (OC)

Soil organic carbon is a measurable component of soil organic matter. Organic matter composes of just 2-10% of the soil's mass and plays important role in the physical, chemical, and biological function of the soils. Organic matter contributes to nutrient retention and turnover, soil structure, moisture retention and availability, degradation of pollutants, and carbon sequestration. SOC is one of the most important constituents of soil due to its capacity to affect plant growth a trigger for nutrient availability through mineralization. Table 3 and Figure 4 depict the organic carbon status in the watershed and classified into three classes viz., low (0.5%), medium (0.5-0.75%), and high (> 0.75%). An area of about 1367 ha (23%) was low (<0.5%) and distributed in the southern and northern parts of the watershed. The maximum area of about 2264 ha (38%) was medium (0.5-0.75%) and distributed in the north and southern portion. An area of about 410 ha (7%) was rated as high and distributed in the northern part of the watershed.

Table 3. Bhagyanagar subwatershed: Organic Carbon (OC) classification

Organic Carbon Classes	Total area in ha (%)
Low (<0.5%)	1367 (22.67)
Medium (0.5-0.75%)	2264 (37.53)
High (>0.75%)	410 (6.8)

Table 4. Bhagyanagar subwatershed: Phosphorus (P2O5) classification

Phosphorus Classes	Total area in ha (%)
Low (< 23 kg/ha)	407 (6.74)
Medium (23-57 kg/ha)	3309 (54.87)
High (>57 kg/ha)	325 (5.39)

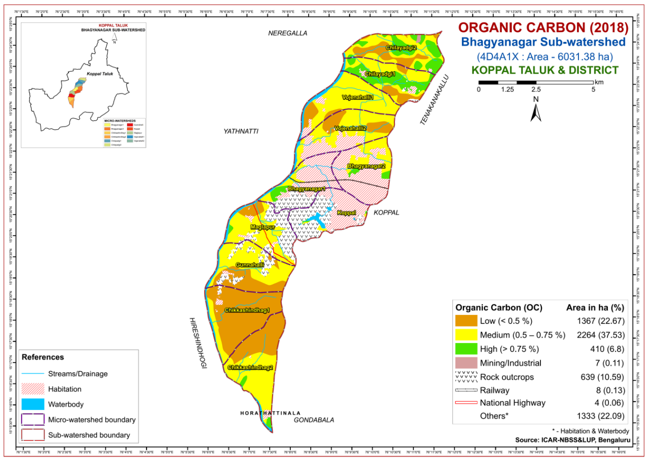

Fig. 4. Organic Carbon (OC) Map of Bhagyanagar Sub-watershed, Koppal Taluk & District

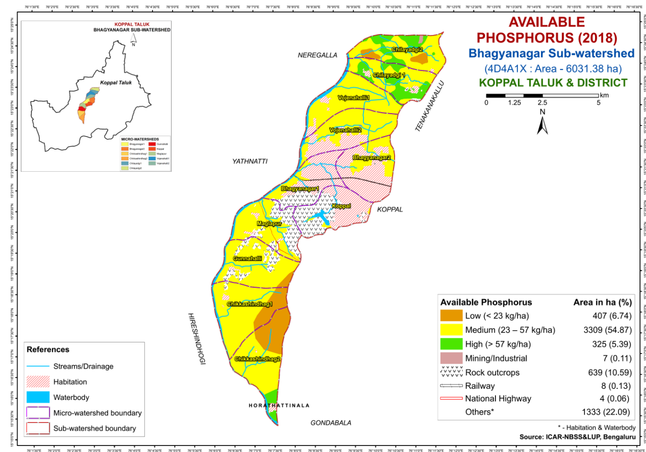

Fig. 5. Phosphorus (PO Map of Bhagyanagar Sub-watershed, Koppal District

Phosphorus (P_2O_5)

Phosphorus is an essential macro-element, required for plant nutrition. It participates in metabolic processes such as photosynthesis, energy transfer and the synthesis and breakdown of carbohydrates. It is found in soils as organic compounds and minerals. Growth slows down and leaves become smaller[(16)] . However, the amount of readily available phosphorus is very low compared with the total amount of phosphorus in the soil. Therefore, in many cases, phosphorus fertilizers should be applied to meet crop requirements. Because phosphorus mobility in soil is very limited, plant roots can only absorb phosphorus only from their immediate surroundings. The availability of phosphorus (P_2O_5) in the soil can be classified into three classes i.e., low, medium, and high. Table 4 and Figure 5 illustrate these categories in the subwatershed. An area of about 407 ha (7%) was rated low (<23 kg ha^{-1}) and 3309 ha (55%) was rated medium (23-57 kg ha^{-1}) in terms of available phosphorus and distributed in the northern and southern part of the watershed and 325 ha (5%) was rated into high (>57 kg ha^{-1}) and distributed in the northern and southern part of subwatershed. It is recommended that areas with high phosphorus content reduce their application of fertilizer by 25% from the recommended amount, and areas with low or medium phosphorus content should add 25%.

Potassium (K_2O)

Plants need potassium to cope with environmental stresses. It improves drought resistance, winter hardiness, and insect pest resistance. As a result, the stem remains slender[(17)]. The availability of potassium in the soil can also be divided into three classes i.e., low, medium and high. Table 5 and Figure 6 show the potassium status and 75 ha (1%) is low (< 145 kg ha^{-1}), 2741 ha (45%) is medium (145-337 kg ha^{-1}) and 1226 ha (20%) was high (>337 kg ha^{-1}) respectively. In areas with high potassium content, reducing the recommended dose by 25% is necessary to avoid excessive fertilizer application, while adding 25% higher potassium to areas with the low or medium potassium content.

Table 5. Bhagyanagar subwatershed: Potassium (K_2O) classification

Potassium Classes	Total area in ha (%)
Low (< 145 kg ha^{-1})	75 (1.24)
Medium (145-337 kg ha^{-1})	2741 (45.44)
High (> 337 kg ha^{-1})	1226 (20.33)

Conclusion

In Bhagyanagar sub-watershed, Koppal District, our investigations on the spatial distribution of major soil nutrients showed that several areas of the sub-watershed are prone to nutrient deficiency for major crops. The Soil reaction (pH)

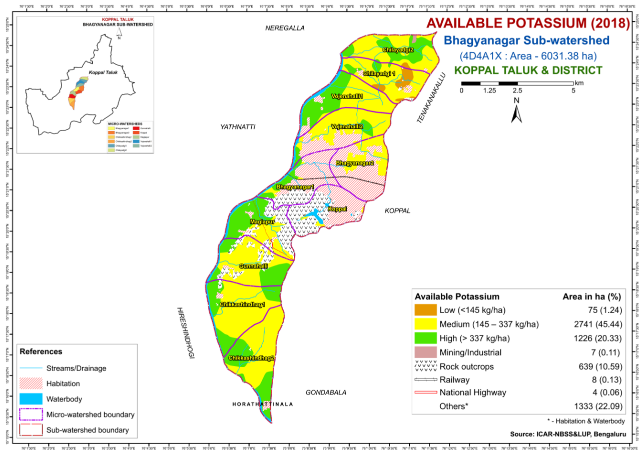

Fig. 6. Potassium (KO Map of Bhagyanagar Sub-watershed, Koppal District

indicated that the soil is strongly acidic to very strongly alkaline, the maximum area had a non-saline soil and low to medium organic carbon status. Available (P2O5) was reported as low in 7%, medium in 55% and high in 5% of the total area; whereas available K2O was reported as medium (45%) and high (20%) in the maximum area. Hence enrichment of soils with deficient nutrients could significantly increase crop productivity and sustainability in the sub-watershed.

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