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Mapping of macronutrient status in soils of Gaganbawda tehsil of Kolhapur district using GPS-GIS technique

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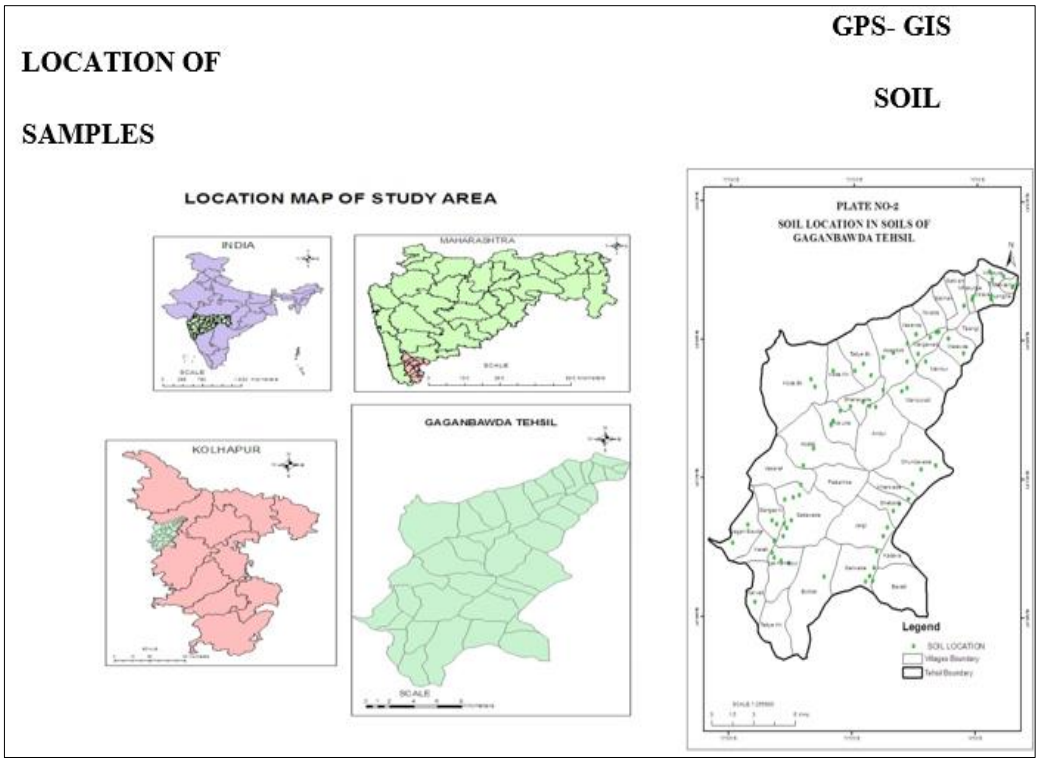
Abstract
The present study entitiled "GPS-GIS based soil fertility maps of Gaganbawda tehsil of Kolhapur district (M.S.)" was conducted during year 2016-2017, by using Global Positioning System (GPS) and Geographical Information System (GIS). Soil samples were analysed for pH, EC,OC, Per cent $CaCO_3$ equivalent, available macronutrients N,P,K,S, Exchangeable Calcium, magnesium and sodium. The availability of macronutrient and their relationship with soil properties were studied. The soil pH varied from 4.86 to 6.94 with a mean value 5.77 and indicated that strongly acidic to slightly acidic in reaction. The EC of soil varied from 0.10 to 0.32 dSm^{-1} (mean value 0.15) and indicated that 100 per cent soils were noraml in nature. The per cen $CaCO_3$ equivalent content and organic carbon content ranged from0.37 to 2.25 and 0.58 to 1.80 per cent with a mean value 1.37 per cent and 1.20 per cent respectively. The soils of Gaganbawda tehsil were baerely calcareous to moderatly calcerous and moderate to very high in organic carbon content. The available macronutrients N, P, K and S ranged from 161.50 to 385.72 kg $ha^{-1,}$ 4.48 to 14.33 kg $ha^{-1,}$ 100.80 to 380.80 kg ha^{-1} and 10.82 to 24.15 mg kg^{-1} respectively. Soils were low to moderate in available nitrogen, very low to moderate in available in phosphrous, moderate to very high in available potassium and moderate to high in available sulphur. The exchangeble calcium, magnesium and sodium ranged from 2.20 to 10.40 [Cmol(p^+) kg^{-1}], 0.30 to 7.10 [cmol(p^+)kg^{-1}] and 0.10 to 0.52 [cmol(p^+)kg^{-1}]. Exchangeable calcium and magnesium were 100% deficient. Organic carbon showed positive significant correlation with available K and negative significant corrleation with sulphur. $CaCO_3$ showed positive significant correlation with potassium, calcium and magnesium.

Keywords: Macronutrient, GPS, GIS, correlation

Introduction
GPS-GIS is advanced tool for studying on site specific nutrient management which can be efficiently used for monitoring soil fertility status in Gaganbawda tehsil of Kolhapur district (M.S.) and it is useful for ensuring balanced fertilization to crops and also for systematic study of nutrients including assessment of primary, secondary and micronutrient status of soil with delineation of areas of nutrient deficiency or sufficiency. Investigation of nutrients status in soils mostly carried out to explain crop failure and to determine the effect on plant growth of elements, other than those already reconginzed. Physical, chemical properties vary from field to field. Spatial tools such as GPS and GIS can be used for storing and analyzing spatial data which will be useful in decision making for agriculture, land development, environment protection and restoration. Land use planners GPS and GIS to assess soil protection of ground water, surface water and wetlands.

Material and Methods
The geographical area of tehsil is 28228 ha. It belongs to western region Maharashtra state and located between 160 54' 35.05'' north latitude and 730 90' 45.5'' east longitude, elevation 80 m from mean sea level. Gaganbawda is situated on the Sahyadri range and fifty five kilometer away from Kolhapur, is non developed, forest and hilly area of district. The climate of Gaganbawda tehsil is hot in summer. During summer highest day temperature is in between 34 ^{0}C to 42 ^{0}C.

Annual average Rainfall is approximately 5000-6000 mm. Climate of Gaganbawda is cool in winter and rainy season. Soil samples collected along with GPS-GIS reading. The processed soil samples were analysed for soil parameter *viz*, pH, EC, OC, $CaCO_3$, available macronutrients, sulphur and exchangeable calcium, magnesium and sodium by using standard analytical methods.



Map 1: Show the location map of study area

Result and Discussion

The pH of the soils of Gaganbawda tehsil of Kolhapur district ranged from 4.86 to 6.94. The soils were strongly acidic to slightly acidic in reaction. Among the soil samples tested, 31 samples (36.48 Per cent) were strongly acidic, 50 samples (58.82 Per cent) were moderately acidic, 4 samples (4.70 Per cent) were slightly acidic in nature The acidic reaction of maximum soil of the tehsil might be due to slopy land and undulating topography, high rainfall leading to leaching losses of bases from the surface soils and accumulation of iron oxides and sesquioxide. The similar results were also recorded by Mishra *et al.* (2014). The EC of soils of Gaganbawda tehsil were ranged from 0.10 to 0.32 dSm^{-1} with average mean value 0.15 dS m^{-1} (normal). These observation indicate that, all the 100 per cent soils were normal, non-saline in nature and suitable for healthy plant growth. The low EC may be due to low temperature, high humidity, light texture of soil, heavy rainfall, high erosion and leaching down of soluble salts. Singh *et al.* (2009) [9] also reported the similar finding in Hoshangabad district of Madhya Pradesh.

Per cent calcium carbonate equivalent content in soils of Gaganbawda Tehsil ranged from 0.37 to 2.25 per cent categorized as barely calcareous to moderately calcareous with the mean value 1.31 per cent (slightly calcareous) Out of all the soil samples collected and analyzed, 25.88 per cent soils were barely calcareous, 71.77 per cent soils were slightly calcareous and 2.35 per cent soils were moderately calcareous. The low calcium carbonate content of soils may be due to low temperature, porous nature of soil, heavy rainfall, high humidity and erosion leads to rapid leaching down of soluble salts and soils basic cations. The similar results were recorded by Singh and Kundu (2010) [10] for north eastern India. The organic carbon status of soil ranged from 0.58 to 1.80 per cent categorized into moderate to very high with the mean value 1.20 per cent (very high). Out of all the soil samples collected and analyzed from Gaganbawda tehsil, 2.35, 8.24, 18.82, 70.59 per cent soil samples under moderatre, moderately high, high and very high category respectively. This might be due to addition of FYM, low temperature, high rainfall, accumulation and decomposition of leaves, organic residues and litters. The low organic carbon content in the soils may be attributed to poor management practices such as lack of addition of crop residues and organic manures. Besides this, intensive cropping is also one of the reason for low organic carbon content. The high content of organic carbon might be due to the addition of organic manures through either artificially or naturally and its subsequent decomposition. (Mandavgade *et al.* 2015) [5].

Table 1: pH, EC and Per cent $CaCO_3$ equivalent status

Particular	pH (1:2.5)	EC (dS m^{-1}) (1:2.5)	Per cent $CaCO_3$ Equivalent
Range	4.86 – 6.94	0.10-0.32	0.37 -2.25
Mean	5.77	0.15	1.31
Category	Strongly acidic 31(36.48%)	Normal 85 (100%)	Barely calcareous 22(25.88%)
	Moderately acidic 50(58.82%)		Slightly calcareous 61(71.77%)
	Slightly acidic 4(4.70%)		Moderately calcareous 2(2.35%)
95% Confidence limit	2.64	0.34	1.88

The available nitrogen content in the soils of Gaganbawda tehsil ranged from 151.60 to 385.72 kg ha^{-1}, categorized as low to moderate with the mean value 321.64 kg ha^{-1} (moderate). Out of 85 soil samples collected and analyzed from Gaganbawda tehsil, it was seen that, 10.59 per cent in low and 89.41 per cent in moderate category. It might be due to the low pH which reduces the degradation of organic matter as compared to Vertisols, that reflect status of available nitrogen. The topography of Gaganbawda tehsil is sloppy and undulating, due to which most of nitrogen leached and eroded with the running water, similar results were observed by Survase *et al.* (2011) [11] in the soils of Panchganga basin of Kolhapur district. Low status of available phosphorus in soil might be due to acidic nature of soil reaction and fixation of phosphorus in acidic soils with aluminium, iron etc. The available potassium in soils of Gaganbawda tehsil was ranged from 100.80 to 380.80 kg ha^{-1} categorized in low to very high with the mean value 188.95 kg ha^{-1} (moderate). Out of 85 soil samples 16.47 per cent in low, 41.18 per cent in moderate, 37.65 per cent in moderately high, 2.35 per cent in high and 2.35 per cent very high in available potassium. Majority of the soils were moderately high and high in available potassium. Adequate available potassium in the soils may be attributed to the prevalence of potassium rich minerals like illite and feldspar (Sharma *et al.* 2008) [8].

Table 2: Status of organic carbon and available nitrogen, phosphorus and potassium status

Particular	Organic carbon (%)	Available nutrients (kg ha^{-1})		
		N	P	K
Range	0.58-1.80	151.60-385.72	4.48-14.33	100.80-380.80
Mean	1.20	321.64	11.42	188.95
Very low	-	-	4(4.70%)	-
Low	-	9 (10.59%)	77 (90.60%)	14 (16.47%)
Moderate	2(2.35%)	76 (89.41%)	4 (4.70%)	35 (41.18%)
Moderately High	7 (8.24%)	_	_	32 (37.65%)
High	16 (18.82%)	_	_	2 (2.35%)
Very high	60 (70.59%)	_	_	2(2.35%)
95% Confidence limit	1.22	234.12	9.85	280

The available sulphur in the soils ranged from 10.82 to 24.15 mg kg^{-1} moderate to high with the mean value 15.74 mg kg^{-1} (moderately high). Among the 85 soil samples collected and analyzed, 52.95 per cent soil samples were in moderate, 35.29 per cent sample in moderately high and 11.76 per cent samples high in sulphur content. The total sulphur in soil was present in organic combination; therefore soils which are rich in organic matter will have high level of sulphur and also coarse texture soils have low amount of sulphur than fine textured soils due to leaching losses and adsorption of sulphates on organic matter leads to unavailable to plants. The similar result were observed by Pulkeshi *et al.* (2012) [7] in soils of Mantangi village of North Karnataka.

Table 3: Status of available sulphur status

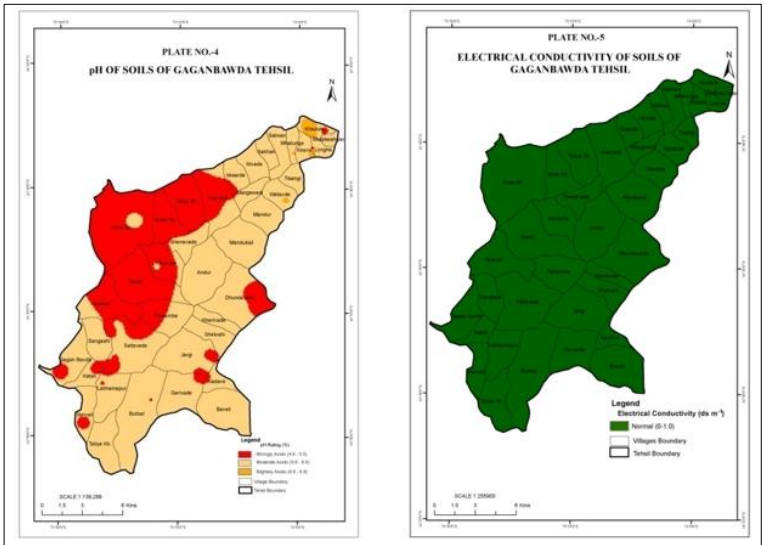
Particular	Available Nutrient
	S (mg kg^{-1})
Mean	10.82-24.15
Range	15.74
Very low	-
Low	-
Moderate	45(52.95%)
Moderately high	30(35.29%)
High	10(11.76%)
Very high	-
95% Confidence limit	5.20

The exchangeable calcium in the soils of Gaganbawda tehsil ranged from 2.20 to 10.40 [cmol(p^+)kg^{-1}] with the mean value 6.78 [cmol(p^+)kg^{-1}] (deficient). Out of 85 soil samples collected and analyzed 100 per cent samples were deficient in exchangeable calcium The deficiency may be due to porous structure of soil, heavy rainfall, erosion and leaching losses of basic cation. The similar result reported by Nayak *et al.*, (2006) [6] in Vidharbha region Maharashtra. The exchangeable magnesium in the soils of tehsil ranged from 0.30 to 7.10 [cmol(p^+)kg^{-1}] with the mean value 3.31 [cmol(p^+)kg^{-1}] (deficient). Out of all the soil samples analyzed, 100 per cent samples were deficient in exchangeable magnesium. The deficiency may be due to porous structure of soil, heavy rainfall, erosion, leaching losses of basic cations and low tempreture condition Mahapatra and Kibe (1973) [4] reported similar results as regards exchangeable magnesium content in soils of Konkan region.

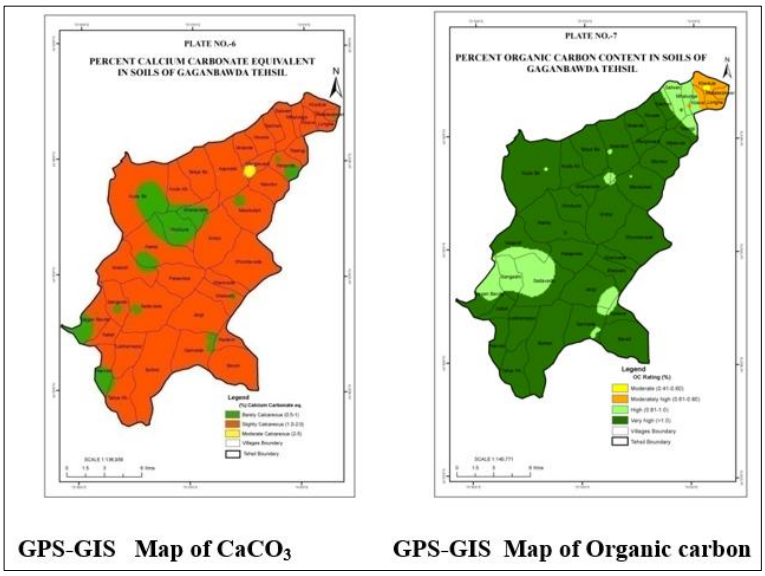
Table 4: Status of exchangeable calcium, magnesium and sodium status

Particular	Exchangeable [cmol(p^+)kg^{-1}]		
	Ca	Mg	Na
Range	2.20-10.40	0.30-7.10	0.10-0.52
Mean	6.78	3.31	0.24
Sufficient	-	-	-
Deficient	85(100%)	85(100%)	-
95% Confidence limit	8.20	6.80	0.42

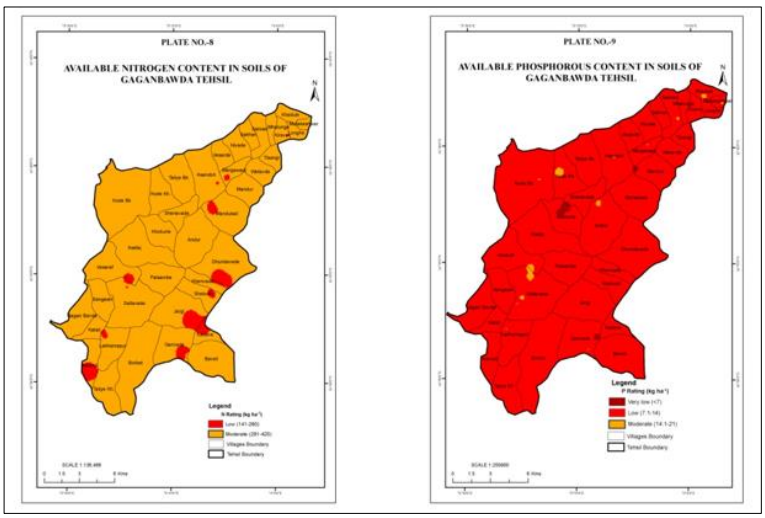
The exchangeable sodium content in the soils of Gaganbawda tehsil ranged from 0.10 to 0.52 [cmol(p^+)kg^{-1}] with the mean value 0.24 [cmol(p^+)kg^{-1}]. This might be due to low temperature, sloppy, undulating land porous nature of soil, heavy rainfall, erosion of nutrients with flowing water, leaching condition. The similar result were reported by Gosavi (2016) [3] for Radhanagari tehsil of Kolhapur.

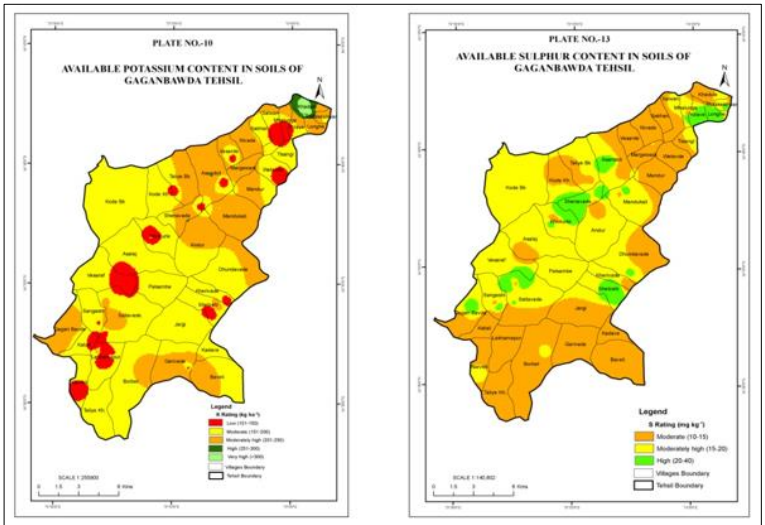


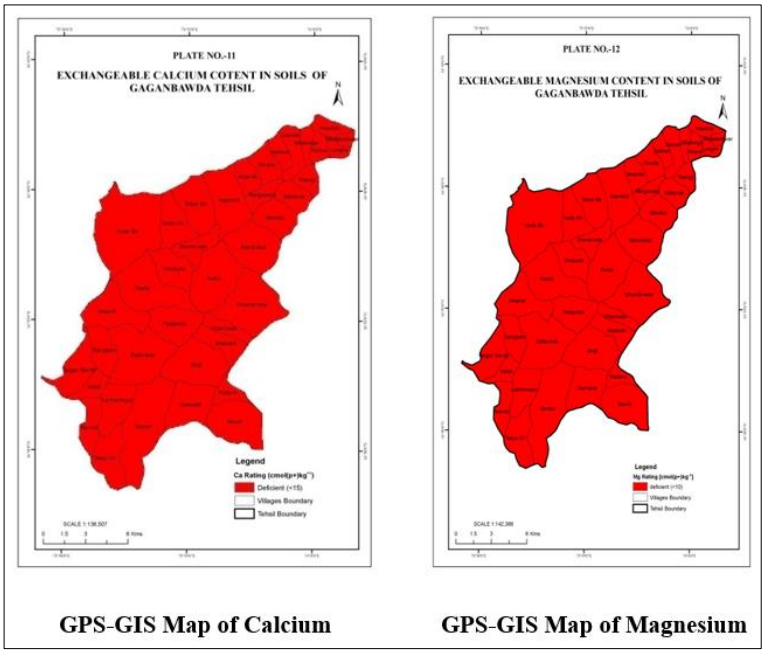
GPS-GIS Map of pH **GPS-GIS Map of EC**



GPS-GIS Map of $CaCO_3$ **GPS-GIS Map of Organic carbon**







Correlation of available macronutrient with soil properties

The correlation of available nitrogen, phosphorus, potassium, sulphur, exchangeable calcium, magnesium and sodium with soil pH, EC, calcium carbonate and organic carbon of soils of Gaganbawda tehsil were calculated. The correlation coefficients between soil properties and nutrients are reported in table 5. The pH of soils showed highly significant positive correlation with calcium (r = 0.239*), magnesium (r = 0.228*) and significant negative correlation with manganese (r = -0.249*). Chaudhari *et al.* (2013) [2] found similar results as significant negative correlation with DTPA extractable micronutrient Mn which is evident from 'r' value of -0.607*. The electrical conductivity of soils showed highly significant positive correlation with manganese (r = 0.239*). Chaudhari *et al.* (2012) [1] found similar results as significant positive correlation between manganese and electrical conductivity (r = 0.9284). Organic carbon content of soils indicates the significant positive correlation with potassium (r = 0.231*), and negative significant correlation with sulphur (r = -0.282**). Per cent calcium carbonate equivalent content of soils of Gaganbawda tehsil showed significant positive correlation with potassium (r = 0.246*), calcium (r = 0.258*), and magnesium (r =0.223*). Chaudhari *et al.* (2012) [1] found similar results as highly significant positive correlation between available potassium $CaCO_3$ (r=0.870)

Table 5: Correlation of available nutrient with soil properties

Chemical properties	Available nutrients (kg ha^{-1})			Exchangeable cations [cmol (p$^+$) kg^{-1}]			Available sulphur (mg kg^{-1})
pH	-0.066	0.102	0.111	0.239*	0.228*	0.208	-0.044
EC	0.115	-0.111	0.158	0.118	0.003	0.102	-0.107
$CaCO_3$	0.026	-0.190	0.231*	0.135	0.141	0.137	-0.282**
OC	0.050	0.180	0.246*	0.258*	0.223*	-0.002	-0.148

*Significant at 5% = 0.214 and ** at 1% level=0.278 (Sample no. 85)

Conclusion

The soils of Gaganbawda tehsil were strongly acidic to slightly acidic in reaction and normal in salt content, moderate to very high in organic carbon content and barely calcareous to moderately calcareous in per cent calcium carbonate equivalent. Available nitrogen values were low (10.59%) to moderate (89.41%) and also found very low (4.70%) to moderate (4.70%) in available phosphorus, where low (16.47%) to very high (2.35%) in available potassium content. All the soil samples were deficient in exchangeable calcium and in exchangeable magnesium content. Available sulphur was moderate (52.95%) to high (11.76%). The pH showed highly significant positive correlation with calcium and magnesium and negative significant correlation with manganese. The EC of soils showed highly significant positive correlation with manganese. Organic carbon content showed highly significant positive correlation with potassium and negative significant correlation with sulphur. Per cent calcium carbonate equivalent had positive significant correlation with potassium, calcium and magnesium.

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