International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 3098-3103

Received: 14-03-2018
Accepted: 19-04-2018

SL Parhad
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India

Nilam B Kondvilkar
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India

SM Khupse
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India

Reshma B Sale
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India

TD Patil
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India

Correspondence
Nilam B Kondvilkar
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India

Management of soil quality through assessment of macro and secondary nutrient status of Sindkheda tehsil of Dhule district (M.S.)

SL Parhad, Nilam B Kondvilkar, SM Khupse, Reshma B Sale and TD Patil

Abstract
The present investigation was carried out during the year 2014-2015 with the aim to study the nutrients status of soils in Sindkheda tehsil of Dhule district for proper soil quality management for better crop production and maintaining soil health. The study area comes under scarcity zone. Total 201 soil samples (0-22.5cm depth) from the 67 villages were analyzed for their fertility status and mapped by geographic information system (GIS) technique. The exact locations of soil samples were recorded with the help of GPS.
The results indicated that all samples were slightly acidic to moderately alkaline in soil reaction (6.62-8.84), non-saline (0.12 -0.86 dS m^{-1}), very low to high in organic carbon (1.1-9.9 g kg^{-1}) and calcium carbonates ranged from (7.75-16.0 %). Regarding to macro and secondary nutrients, the available N, P and K which ranged between (125.44-288.51 kg ha^{-1}), (5.36-30.74 kg ha^{-1}) and (204.8-604.8 kg ha^{-1}), respectively, whereas exchangeable Ca (20.0-35.8 cmol (p^+) kg^{-1}) and Mg (10-19.8 cmol (p^+)kg^{-1}) was sufficient in soils and available S is ranged between (7.8-45.56 mg kg^{-1}) was slightly deficient to sufficient in soil.

Keywords: GPS-GIS, Soil fertility status, mapping, nutrient management and soil quality

Introduction
Soil fertility is one of the important factors controlling the crop yield. Soil related limitations affecting the crop productivity including nutritional disorders can be determined by evaluating the fertility status of the soils. Soil testing provides the information about the nutrient availability of the soil upon which the fertilizer recommendation for maximizing crop yield is made.
The objective of soil survey and mapping is to organize soil observations and knowledge of soil to remember important characteristics of soils, establish environmental and other relationships and to develop principle guidelines for management of soil resources. Soils are considered as the integral part of the landscape and their characteristics are largely governed by the landforms in which they are developed. Topographic maps, aerial photographs and remote sensing data provide useful tools for geomorphic analysis of the region and help in the soil survey and mapping (Pandey and Pofali, 1982) [20]. The remote sensing techniques in conjugation with conventional methods have been employed successfully in India and different parts of the world (Sehgal *et al*., 1988) [3].
Soils of Maharashtra State are categorized as poor in fertility and vary widely in genetic, morphological, physical, chemical and biological characteristics (Challa *et al*., 1995) [3]. The deficiencies of nutrients started appearing in different areas due to introduction of intensive production systems after green revolution period. It is due to net removal rates of micronutrients by crops being higher under intensive productivity regimes (Kanwar, 2004) [16]. The situation was further intensified by discontinuous and diversified use of organic manures and chemical fertilizers.
Recently GPS units are becoming smaller and less expensive. There are an expanding number of applications for GPS. In transportation GPS applications assists pilots and drivers in pinpointing their location. Farmers can use GPS to locate the nutrient deficiencies and can manage the accurate distribution of fertilizer chemicals. The present study of "GPS-GIS based soil fertility maps of Sindkheda tehsil of Dhule District (M.S)" was conducted to study the soil properties with the major emphasis on nutrient status of soils.

Material and Methods

Location

Sindkheda tehsil is located in between 21°16'0" N Latitude and 74°44'00" E Longitude. The total geographical area of Sindkheda tehsil is 1,30,613 ha Sindkheda tehsil is located near national highway number three.

Geology

Soils are resultant of the igneous rocks *viz.* basalt (Deccan trap) which is basic in nature containing mainly feldspars (plagioclase), augite and small amount of titaniferrous magnetite mineral. In the vesicular rocks cavities are filled with minerals like zeolite and quartz.

Hydrology

The well and Tapi river are main source of irrigation in Sindkheda tehsil. Total area under irrigation is 31,763 ha.

Climate

The climate of Sindkheda tehsil is hot and dry. Agro climatically, Sindkheda comes under agro ecology situation (AES-2) scarcity zone. Nearly 130053 ha (16.12%) come under scarcity zone. The average annual rainfall is 538 mm out of which 75 per cent rainfall is received in monsoon period, 17 per cent is received in post monsoon period and 8 per cent is received in pre monsoon period. About 65 per cent of the annual rainfall is received in July and August. In the remaining period there is practically a dry spell with abundant sunshine and clear sky, Very scanty but occasional rains are during summer season and hence, assured irrigation facilities are needed for growing summer crops. The annual average maximum and minimum temperature was 42^0 C and 12^0 C, respectively. The area therefore, qualified for "hyperthermic" temperature regime.

Land use and natural vegetation

The main agronomical crops are grown in kharif season viz. cotton, sorghum, bajra, maize, soybean, green gram, red gram. The crops are grown in *Rabi* season *viz.* wheat, maize, gram etc. The area under kharif and *Rabi* season are 1, 03,895 and 15,325 ha, respectively. The main horticultural crops *viz*., fruits like papaya, banana, ber, custard apple, pomegranate, citrus, guava, lemon and vegetables are onion, chilli, etc. The area under horticulture fruits and vegetables is 4,150 and 3,800 ha, respectively. The natural vegetation consists of dry deciduous tree species (Eucalyptus, neem etc). Open area is 15879 ha reported and grazing area is 6050 ha. Non agriculture use area is 319 ha.

Methodology

Soil sample collection and analysis

Geo-referenced surface (0-22.5cm) soil samples representing different survey numbers were collected from Sindkheda Tehsil. The soil samples were collected at 0-22.5 cm depth by using systematic sampling methodology based on GPS.

1. The soil sample at 8 x 8 km apart grid points were decided and the soil samples from each point was collected.
2. Total 201 surface soil samples were collected.
3. Recorded the latitude and longitude, elevation, vegetation and location,
4. The soil samples were collected with plastic spade.

Soil samples were analyzed for chemical characteristics by following standard analytical techniques. Soil reaction was determined in 1:2.5 suspension using standard pH meter by potentiometry (Jackson, 1973) [11]. The electrical conductivity was determined by 1:2.5 suspension using EC meter by Conductometry (Jackson, 1973) [11]. Soil organic carbon was estimated using the wet oxidation method (Nelson and Sommer, 1982) and $CaCO_3$ is determined by Acid neutralization method by Alison and Moodie (1965) [1].

Soil available N determined by Modified alkaline permanganate Subbiah and Asija (1956), available P by 0.5M $NaHCO_3$ (Watanabe and Olsen, 1965) and available K by Flame Photometer (N*N*NH_4OAc pH (7.0), (Jackson, 1973) [11]. Available S determined by 0.15% $CaCl_2$ extractable method by William and Steinberg (1969) [30] and exchangeable Ca and Mg determined by Versenate titration method given by Hoffman and Shapiro (1954) [10].

Generation of Maps

The delineation of the area for different nutrient levels of soils and their extent of area were calculated and mapping was carried out by using Arc-GIS 9, version 9.3 software.

Statistical Analysis

The soil chemical properties data were statistically analyzed by using standard statistical methods given by Panse and Sukhatme (1985) [21].

Result and Discussion

Chemical characteristics of soil

Table 1: Soil pH, EC, Organic Carbon and $CaCO_3$ status of Sindkheda Tehsil

Particulars	pH	EC (dSm^{-1})	Organic Carbon (g kg^{-1})	$CaCO_3$ (%)
Mean	7.79	0.37	6.8	10.77
Range	6.62 – 8.84	0.12- 0.86	1.1-9.9	7.75-16.0
SE±	0.02	0.01	0.01	0.12

Soil pH

The pH of the Sindkheda ranges from 6.62 to 8.84 and the mean was 7.79, among the soil samples tested, 04 (1.99%) were slightly acidic, 127 (66.19%) were slightly alkaline and 70 (34.82%) soil samples were moderately alkaline. The highest soil pH (8.84) was observed in soil sample taken at Sukavad (21017.064|N – 074048.839|E) and lowest soil pH (6.62) was observed at Sonshelu village (21011.524|N–074039.012|E). The similar natures of observation for soil pH were also recorded by Kadu (2007) in soils of Parola tehsil of Jalgoan District and Jibhakate *et al.* (2009) [13] in soils of Katol tehsil of Nagpur District. Soils are in general alkaline in nature, it might be due to medium deep black soils brought under irrigation since long have shifted to alkaline condition and soil had pH less than 8.0 might be due to soil having well drained condition and light in colour. The data indicate that soils were slightly to moderately alkaline in respect of soil reaction.

Electrical conductivity (EC)

The EC of various soil samples were ranged from 0.12 to 0.86 dSm^{-1}, the lowest (0.12 dSm^{-1}) was recorded at Mhalsar village (21013.710|N-074055.392|E) and highest (0.86 dSm^{-1}) at Betawad village (21010.395|N-074054.319|E). The mean of EC for all soil samples was 0.37 dSm^{-1}. It is observed that all 201 soils (100 per cent) were non saline in nature. The similar results were reported by Waikar *et al*. (2004) [28] for the soils of Maharashtra. The EC indicated that all 201 the soils were normal in respect of salt content and hence suitable for healthy plant growth.

Organic Carbon

The organic carbon content ranged from 1.1 g kg^{-1} to 9.9 g kg^{-1} with the mean of 6.8 g kg^{-1}. The highest content of organic carbon was (9.9 g kg^{-1}) was observed for soil at Darkhede village (21012.714|N-074042.959|E) and the lowest (1.1 g kg^{-1}) organic carbon was observed at Dalwade village (21010.389|N- 074041.498|E). Out of the total soil samples analyzed and categorized for organic carbon, 5 soil samples (2.49 %) soils were in very low organic carbon content; 02 soil samples (0.99%) soil in low category, 50 soil samples (24.87%) soils in moderately, 111 soil samples (55.23%) in moderately high category and 33 soil samples (16.42%) in high. The similar observations were recorded for organic carbon by Ghuge (2002) [9] in soils of Vertisols, Inceptisols and Entisols of Ujana (Ahmadpur), Chaudhari and Kadu (2007) [5] in soils of Dhule tehsil of Dhule district, Sharma *et al.* (2008) [24] in soils of Amritsar district and Chandrakar *et al.* (2013) [14] in Inceptisol of Akaltara block of Janjgir district of Chhattigarh. The moderate to moderately high organic carbon content might be due to high temperature prevailing during the summer under the semi-arid climate of Sindkheda Tehsil which favours for high rate of decomposition of organic matter in soil.

Calcium Carbonate

The calcium carbonate in soils of Sindkheda tehsil of Dhule district ranged from 7.75 to 16.0 per cent with an average of 10.77 per cent. Out of total soil samples, 75 (37.31%) soil samples were high in calcium carbonate content and 126 (62.69%) soil samples in very high category. The highest calcium carbonate was (16.0 %) in soil collected at Mandal village (21018.246|N-074034.469|E) and the lowest (7.75 %) in soil samples at Bramhane village (21020.572|N-074037.220|E). The similar nature of observation for $CaCO_3$ in soils of Shevgaonn tehsil of Ahmednager District was reported by Dhage *et al*. (2000) [7]. Out of total soil samples, 126 (62.69%) soil samples were under very high category. The calcareousness of soils are common feature in soils of arid and semi-arid climate particularly in Vertisols (black soils) due to precipitation of carbonates and bicarbonates under water stress.

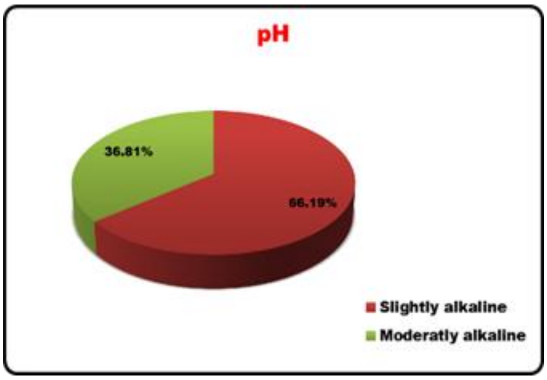

Fig 1: Soil pH status of Sindkheda Tehsil

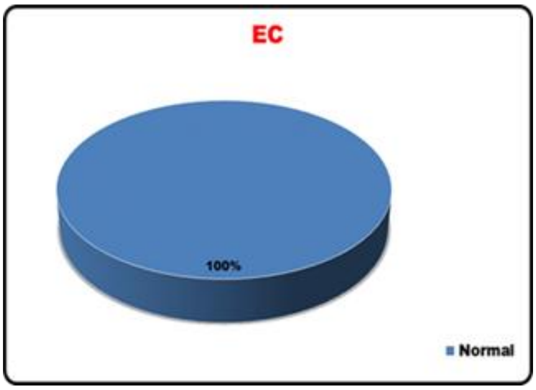

Fig 2: Soil Electrical Conductivity (dSm^{-1}) status of Sindkheda Tehsil

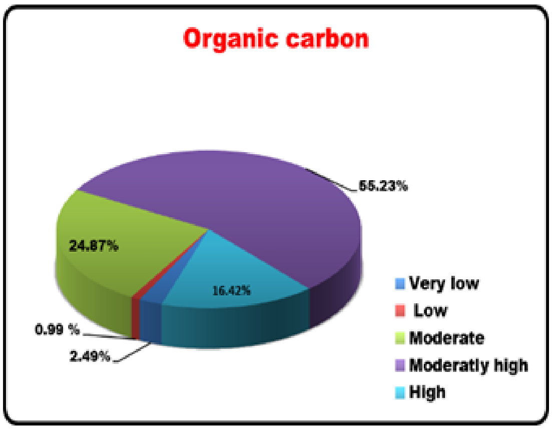

Fig 3: Soil Organic Carbon (g kg^{-1}) status of Sindkheda Tehsil

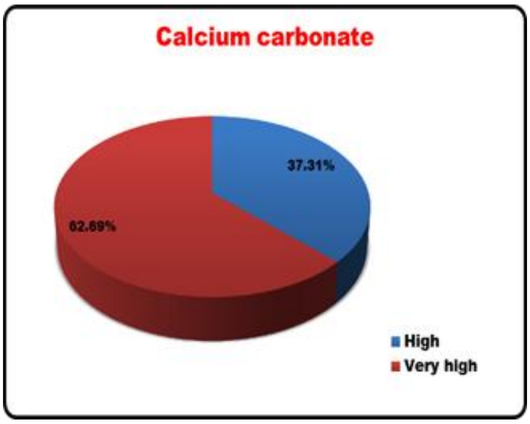

Fig 4: Soil Calcium Carbonate (%) Status of Sindkheda Tehsil

Primary Nutrients

Nitrogen

The available nitrogen in soils ranged from 125.44 to 288.51 kg ha^{-1} with an average of 213.87 kg ha^{-1}. Out of the total, 23 soil samples (11.44%) as very low, 160 soil samples (79.60%) were categorized as low in available nitrogen, and 18 soil samples (8.96%) were moderate. The highest available nitrogen content (288.51 kg ha^{-1}) was observed in soil at Kanchanpur village (21005.826|N-074052.066|E) while lowest (125.44 kg ha^{-1}) recorded in soil at Mhalsar village (21013.710|N074055.392|E). The similar results were recorded by Kadam (1993) in soils of Jalna District (M.S), Ghuge (2002) [9] in soils Vertisols, Inceptisols and Entisols of Ujana (Ahmadpur), Waikar *et al*. (2004) [28] in soils of Maharashtra region and Jibhakate *et al.* (2009) [13] in soils Katol tehsil of Nagpur District.

The low available nitrogen in most of the soils might be due to the higher temperature in semi-arid climate of Sindkheda tehsil, which might have declined the organic matter status by faster degradation resulted in low status of available nitrogen.

Phosphorus

The available phosphorus in soils were ranged from 5.36 to 30.74 kg ha^{-1} with an average of 16.32 kg ha^{-1}. Among the total 5 soil samples (2.49%) were in very low category whereas, 62 (30.85%) soil samples in low, 105 (52.24%) soil samples in moderate and 27 (13.44%) soil samples in moderately high category and 2 (0.99%) soil samples in high category. The highest available phosphorus (30.74 kg ha^{-1}) was observed in soil at Dabhashi village (2105.358|N-074051.405|E) and lowest (5.36 kg ha^{-1}) in soil at Dalwade village (21010.744|N074041.776|E). The similar trends of available phosphorus were also reported by Ratnakumari *et al*. (2006) in soils Guntur District of Andhra Pradesh, Bidari *et al*. (2008) [2] in soils of Dharwad District in North Karnataka and Devdas *et al.* (2013) [6] in soils of Navagarh block under Janjgir District of Chhattisgarh. Low status of soil available P in soils of studied area might be due to alkaline soil reaction and high content of $CaCO_3$ in the soil and may not be use of SSP by farmers.

Table 2. Soil available N, P and K status of Sindkheda Tehsil

Particulars	Available Nutrients (kg ha^{-1})		
	N	P	K
Mean	213.87	16.32	319.52
Range	125.44-288.51	5.36-30.74	204.8-604.8
SE±	3.55	0.35	6.14

Potassium

The available potassium in soils was ranged from 204.8 to 604.8 kg ha^{-1} with an average of 319.52 kg ha^{-1}. The highest available potassium was (604.8 kg ha^{-1}) in soil at Dabhashi village (21015.584|N074051.862|E) while, lowest was (204.8 kg ha^{-1}) in soil at Dongargao village (21004.850|N-074052.056|E). Most of the soil samples shown high to very high category of available potassium. Out of the total soil samples, 46 (22.88%) were found moderately high category, 56 (27.86%) soil samples in high category and 99 (49.26%) soil samples were in very high category in respect of available K. The similar trends of available potassium were reported by Waikar (2004) [28] in soils of Northen Marathwada region and Jibhakate *et al.* (2009) [13] in soils of Katol tehsil of Nagpur District. The high content of available K in the soil could be attributed due to the dissolution and diffusion of K from internal crystal lattice of silicate clay minerals under the condition of high clay content especially of montmorillonite clay minerals present in soil (Durgude, 1999) [8].

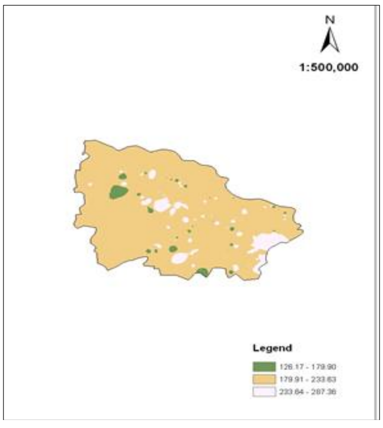

Fig 5: Soil available Nitrogen (kg ha^{-1}) status of Sindkheda Tehsil

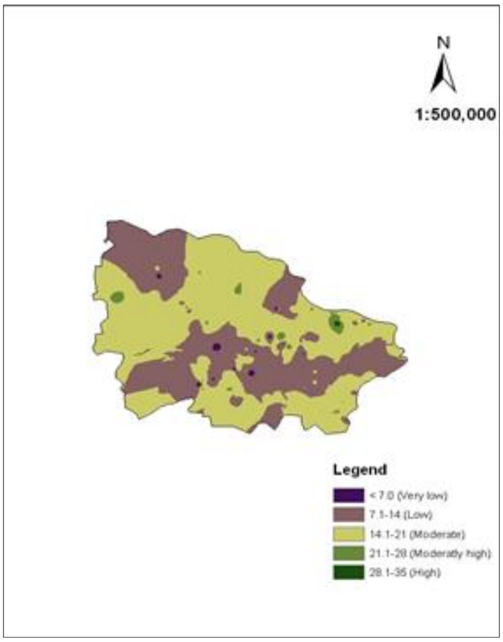

Fig 6: Soil available Phosphorus (kg ha^{-1}) status of Sindkheda Tehsil

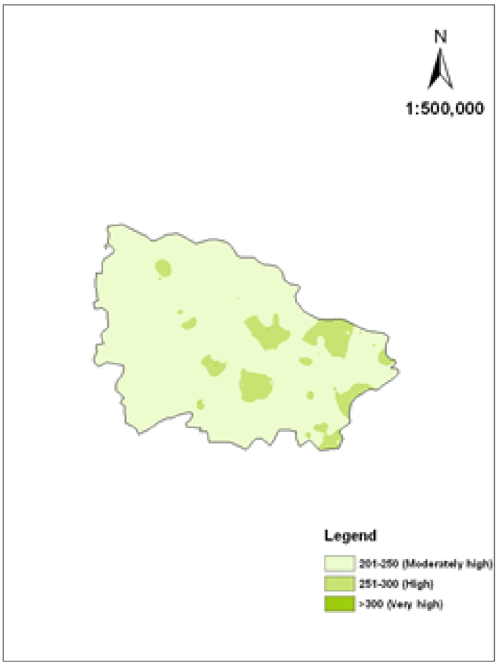

Fig 7: Soil available Potassium (kg ha^{-1}) status of Sindkheda Tehsil

Secondary nutrients

Calcium

The exchangeable calcium in soils ranged from 20.0 to 35.80 [cmol (p+) kg^{-1}] with an average of 27.25 [cmol (p+) kg^{-1}]. Out of total soil samples all soil samples (100%) sufficient in exchangeable calcium, as the critical limit of available calcium is 20 [cmol (p+) kg^{-1}]. The highest exchangeable calcium 35.80 [cmol (p+) kg^{-1}] was in soil of Aalne village (21013.274|N-074042.984|E) while, lowest was 20.0 [cmol (p+) kg^{-1}] in soil of Patan village (21068.09|N-074045.896|E). The similar trend were also recorded by Nayak *et al.* (2006) [17] in swell and shrink soils of Vertisol order in Vidarbha region and Tripathi and Sawarkar (2007) [27] in soils Vertisol pedons of Kymore plateau in Jabalpur District. The higher amount of exchangeable Ca content found in soils under study may be due to high clay content and calcareous parent material.

Magnesium

The exchangeable magnesium in soils were ranged from 10.00 to 19.80 [cmol (p+) kg^{-1}] with an average of 13.46 [c mol (p+) kg^{-1}]. All most the soil samples (100%) were in sufficient category. The highest exchangeable magnesium 19.80 [c mol (p+) kg^{-1}] was in soil at Sulbhane village (21016.810|N-074046.734|E) and lowest 10.00 [cmol (p+) kg^{-1}] in soil at Vikvel village (21014.956|N-074054.711|E). The similar results were observed by Nayak *et al.* (2006) [17] in swell and shrink soils of Vertisol order in Vidarbha region. Most of the soils 201 (100%) were in the sufficiency range of magnesium may be due to its genesis in the semiarid area.

Table 3: Exchangeable Ca and Mg and available S status of soils of Sindkheda Tehsil

Particular	Exchangeable Ca [cmol (p+) kg^{-1}]	Exchangeable Mg [cmol(p+) kg^{-1}]	Available S (mg kg^{-1})
Mean	27.25	13.46	23.47
Range	20.0-35.8	10-19.8	7.8-45.56
Critical limit	20	10	10
SE±	0.25	0.15	0.72

Sulphur

The available sulphur in soils ranged from 7.8 to 45.56 mg kg^{-1} with an average of 23.47 mg kg^{-1}. Among the samples,39 (19.40%) soil samples were moderate category, 13 (6.46) soil samples were moderately high category, 121 (60.20%) soil samples were high category and only one (0.49%) soil sample were very high category. Out of the total soil samples, 27 (13.44 %) soil samples were deficient and 174 (86.56%) soil samples in sufficient for available sulphur, as the critical limit of available sulphur is 10 mg kg^{-1}. The highest available sulphur recorded was 45.56 mg kg^{-1} in soils at Hatnur village (21012.873|N074040.219|E) while, lowest 7.5 mg kg^{-1} in soil at Gorane village (21009.585N-074048.816|E). The most of sulphur in soil is in organic combination; therefore, soils which are rich in organic matter will have high level of sulphur. Also the coarse-textured sandy soils generally have low total S-content as compared to fine textured soils. However, sufficiency of available sulphur is directly proportional to the organic matter content of the soil. The similar results were found by Jat and Yadav (2006) [12] in soils of Entisols of Jaipur District, Rajasthan and Singh and Singh (2007) [25] in soils of mid-Western Uttar Pradesh. The data indicates majority of soils were sufficiency in range, it might be due to moderate to high content of organic carbon and fine texture of soils.

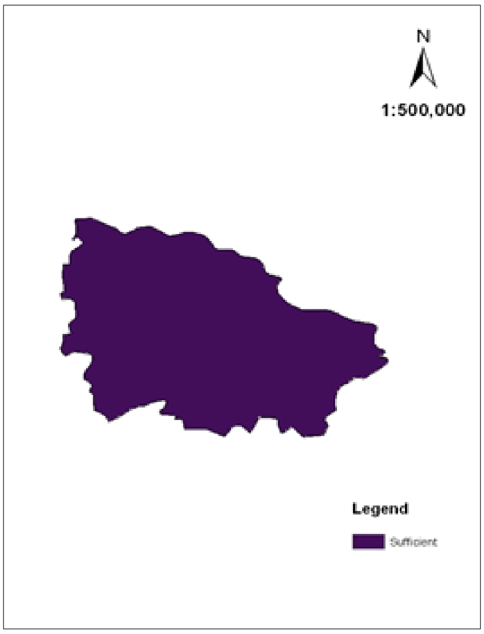

Fig 8: Soil Exchangeable Calcium [cmole(p$^+$)kg^{-1}] status of Sindkheda Tehsil

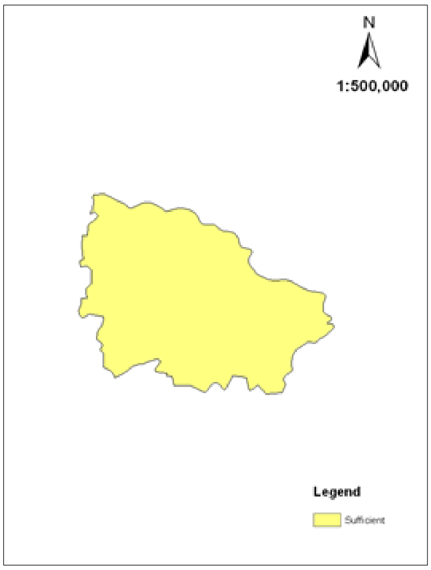

Fig 9: Soil Exchangeable Magnesium [cmole(p$^+$)kg^{-1}] status of Sindkheda Tehsil

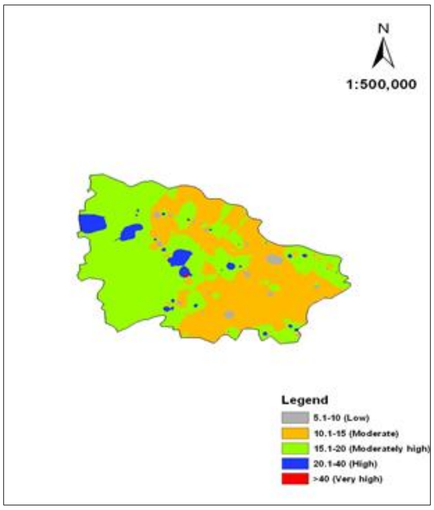

Fig 10: Soil available Sulphur (mg kg^{-1}) status of Sindkheda Tehsil

Conclusion

From the study, it can be concluded that, the soils collected from Sindkheda of Dhule district were moderately to slightly alkaline in reaction and normal in electrical conductivity. The soils were very low to high in organic carbon and high to very high in calcium carbonate. The soils were very low to moderate in available nitrogen, very low to moderately high in available phosphorus and moderately high to very high in available potassium. The soils were sufficient in exchangeable calcium, magnesium and available sulphur.

References

1. Alison LE, Moodie CD. Carbonate *In:* Methods of Soil Analysis. Chemical and Microbiological Properties. Part-II Black C.A. (Ed.). Am. Soc. Agron. Inc. Madison, Wisconsin, USA. 1965, 1387-1388.
2. Bidari BI, Math KK, Ninganur BT. Physico-chemical properties and nutrient status of soil profiles producing varying quality chillies in Dharwad, Karnataka. Asian J Soil Sci. 2008; 3(2):336-342.
3. Challa O, Vadivelu S, Sehgal JT. Soils of Maharashtra for optimizing land use. NBSS Pub: 54 (soils of India series). NBSS and Land Use Planning Nagpur, India. 1995; 112.
4. Chandrakar Kunal, Srivastava LK, Deepika Devdas. Estimation of available micronutrients on the basis of correlation between physico-chemical properties of pH, EC, OC and available Fe, Mn, Cu and Zn in inceptisol of Akaltara block of Janjgir district of Chhattisgarh. Asian J Soil Sci., 2013; 8(2):416-418.
5. Chaudhari RD, Kadu PP. Assessment of fertility status of the soils of Dhule tahsil of Dhule district. Paper presented in state level seminar on soil health enhancement for food and environmental security, organized by PCISSS, at Marathwada Agril. Univ. Parbhani. 2007; 12&13:2.
6. Devdas Deepika, Srivastava LK, Verma U. Study on correlation between physico-chemical properties of pH, OC and available N, P and K in black soil of Navagarh block under Janjgir district in Chhattisgarh. Asian. J Soil Sci., 2013; 8(2):381-384.
7. Dhage AR, Mane SR, Adsule RN. Available micronutrients in the soils of Shevgaon tehsil (Ahemadnagar Dist.) in relation to soil characteristics. J Maharashtra agric. Univ. 2000; 25(1):97-98.
8. Durgude AG. Morphology, Characterization, classification and mapping of salt affected soils of Central Campus, Research Farms, Mahatma Phule Krishi Vidyapeeth, Rahuri. Ph.D. Thesis submitted to MPKV, Rahuri (M.S.) India, 1999.
9. Ghuge SD. Fertility status of sugarcane growing soils under Balaghat Shetkari Co-operative sugar factory Ujana. M.Sc. (Agri) Thesis submitted to Marathwada Agriculture University., Parbhani. (M.S) India, 2002.
10. Hoffman WM, Shapiro H. Some observation on the Versenate Method for calcium and magnesium in agricultural liming material. J Assoc. off. Agric. Chem. 1954; 37:966-971.
11. Jackson ML. Soil Chemical Analysis, prentice Hall of India. Pvt. Ltd., New Delhi, 1973, 498.
12. Jat JR, Yadav BL. Different forms of sulphur and their relationship with properties of Entisols of Jaipur District (Rajasthan) Under Mustard cultivation. J Indian Soc. Soil Sci. 2006; 54(2):208-212.
13. Jibhakate SB, Bhende SN, Kharche VK, Selvalakshmi V. Physic-chemical status of soils of Katol tehsil in Nagpur district. J. Soils and crops 2009; 19(1):122-128.
14. Kadam BP. Characterization of sugarcane growing soils of Jalana district. M.Sc. (Agri) Thesis submitted to Marathwada Agriculture University., Parbhani. (M.S) India, 1993.
15. Kadu PP. A survey of fertility status of soils of Parola tahsil of Jalgaon district. Paper presented in state level seminar on soil health enhancement for food and environmental security, organized by PCISSS, at Marathwada agril. Univ. Parbhani. Oct. 12 and 13, 2007 Abst. 2007, 4.
16. Kanwar JS. Address by the guest of honour, 69th annual convention of the Indian Society of Soil Science held at the Acharya N.G. Ranga Agricultural University (ANGRAU). Hydrabad. J Indian Soc. Soil Sci, 2004; 52:295-296.
17. Nayak AK, Chinchmalatpure Rao R, Gururaja G, Verma AK. Swell-shrink potential of Vertisols in relation to clay content and exchangeable sodium under different Ionic Environment. J Indian Soc. Soil Sci. 2006; 54(1):1-5.
18. Nayak AK, Chinchmalatpure Rao R, Gururaja G, Verma AK. Swell-shrink potential of Vertisols in relation to clay content and exchangeable sodium under different Ionic Environment. J Indian Soc. Soil Sci. 2006; 54(1):1-5.
19. Nelson DW, Sommer LE. Total carbon and organic matter. In: Methods of Soil Analysis part-II. Page, A.L. (Ed.). Agron. Mono. No. 9 Am. Soc. Agron. Madison, Wisconsin. 1982, 185-187.
20. Pandey S, Pofali RM. Soil-physiography relationship. In:Review of soil research in India. Part II. XII International Congress of Soil Science, New Delhi, India, 8-16 February, 1982, 572-584.
21. Panse VG, Sukhatme PV. Statistical method of agricultural Workers. ICAR, New Delhi. 1985, 143-147.
22. Ratna Kumari S, Subbaramaniam P, Narisi Reddy A. Survey on fertility status of cotton growing soils of Guntur district in Andhra Pradesh. Indian J Agric. Chem. 2006; 39(1):17-24.
23. Sehgal JL, Sharma DK, Karale RL. Soil resource inventory of Punjab using remote sensing technique. J Indian Soc. Remote Sensing. 1988; 16:39-47.
24. Sharma PK, Sood A, Setia RK, Tur NS, Mehara D, Singh H. Mapping of micronutrients in soils of Amritsar district (Punjab): A GIS approach. J Indian Soc. Soil Sci. 2008; 56(1):34-41.
25. Singh KK, Singh R. Distribution of Nitrogen and Sulphur forms in soil profiles of Mid-western Uttar Pradesh. J Indian Soc. Soil Sci., 2007; 55(4):476-480.
26. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956; 25:259-260.
27. Tripathi PN, Sawarkar SD. Morphology, physicochemical properties and classification of some Vertisols of kymore plateau. J Soils and Crops, 2007; 17(2):237-240.
28. Waikar SL, Malewar GU, More SD. Elemental composition of humic and fulvic acid in soils of Marathwada region of Maharashtra. J Maharashtra agric. Univ. 2004; 29(2):127-129.
29. Watanabe FS, Olsen SR. Test of ascorbic acid methods for phosphorus in water and Sodium bicarbonate extract of soil. Proc. Soil Sci. Am. 1965; 21:677-678.
30. William CH, Steinberg A. Soil sulphur fraction as chemical indices of available sulphur in some Australian soil. Aus. J Agric. Res. 1959; 10:340-352.