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Particle Size Analysis of Soils and Its Interpolation using GIS Technique from Sangamner Area, Maharashtra, India

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Abstract

Soil is a substantial resource and displays adaptable physical, chemical, mineralogical, hydrological and geochemical properties. Particle size of any soil determines the productivity of crops. The soil textural distribution information is important for planning agriculture crop production, irrigation management, hydrological analysis and soil characteristics determination. However, high resolution soil particle information obtaining through manually field survey is time consuming and expensive. In view of this studies were carried out to know the particle size characteristics of soil in relation to soil textural and fertility status of Sangamner area of Ahmednagar district in Maharashtra. For this purpose particle size analysis (PSA) was determined from 62 soil samples and interpolated in Geographic Information System (GIS) software using kriging method. It gave the micro level particle size analysis information at enough and accurate scale. These information will become important in contribute to the societal demands and sustainable soil management in study area.

Keywords: Particle size analysis (PSA), GIS, Interpolation, Kriging Method.

Introduction

The earth environment accomplish by soil which is considered as the skin of the earth. It has interfaces with the lithosphere, hydrosphere, atmosphere, and biosphere. The Particle size analysis (PSA) is expressed in classes of which the relative properties can be summed up in the form of triangular diagram enabling the texture of a soil sample. Soil texture is one of the important properties of soil maps and is defined as relative proportions of clay, sand and silt contents. Soil texture has an extremely significant influence on the physical and mechanical behaviours of the soil and on all the properties related to water content and the movement of water[1.] Soil texture directly affects the porosity of soil, which in turn, determines its water-retention, flow characteristics, rate of water intake, nutrient-holding capacity and long-term soil fertility[2]. It also determines the soil erodibility and thus, affects the risk of soil erosion. The interaction of soil clay with nutrient ions, water and organic substances determines the soil fertility, which in turn largely controlled by the quality and nature of minerals[3]. Land use capability and soil management practices are also determined by the texture. Spatial distribution and surface modeling of soil properties has become a common topic in soil science research[4]. It is a useful tool for soil characteristic property interpolation in precision agriculture and soil management. Many researchers have studied the soil textural characteristic and its interpolation using GIS techniques[5-9].

The soils of Sangamner area mainly derived from the Deccan basalt. As far as Sangamner area is concerned, it has unique landforms configuration displaying prohibitive slopes along with typical climatic condition characterised by scanty and low rainfall. It forms typical semi-arid-arid ecosystem. Hence, it is more fragile and prone to degradation even with slight mismanagement. In general, the soil from the study area shows the presence of calcrete (both nodular as well as powdery), the mixture of clay, sand and silt besides the fragments of weathered basalt[10]. The area is also suffering the problem of salinization, alkalization, water logging etc. due to over irrigation, excess use of chemical fertilizer and intensive cultivation[11]. There is few published literature available on the PSA and its interpolation feature of Sangamner area. In view of this, it was decided to study PSA of soils and its interpolation using GIS techniques for pedological, hydrological and agronomical interpretation of soil in study area.

The Study Area: Geographically present area located in Sangamner Tehsil of Maharashtra around the Pravara river bank. The extent of study area is 19° 26' 02.67" to 19° 39' 51.59" north latitude and 74° 03' 14.49" to 74° 23' 17.60" east longitude (Fig.1). The area is drained by the Pravara River which originates in the mountainous region of Ratangarh and flows into low-lying fertile alluvial plain in the downstream part (mature stage)[12]. The study area is located close to the Western Ghats Escarpment (WGE). This area has moderate relief and the soil formed from weathering process of basalt. The basalt flows are nearly flat-lying (the sequence has a regional southerly dip of 0.5°– 1°) and mainly belong to the Thakurvadi Formation (Fm.) of the Kalsubai subgroup. Extensive colluvio-alluvial deposits (locally up to 30 m. thick) of the late quaternary Pravara formation overlie the basalts along the Pravara River and its tributaries[13]. The textural variation in the study area is due to the wide-ranging physiographic dissimilarity, which is responsible to differentiates soils characteristics.

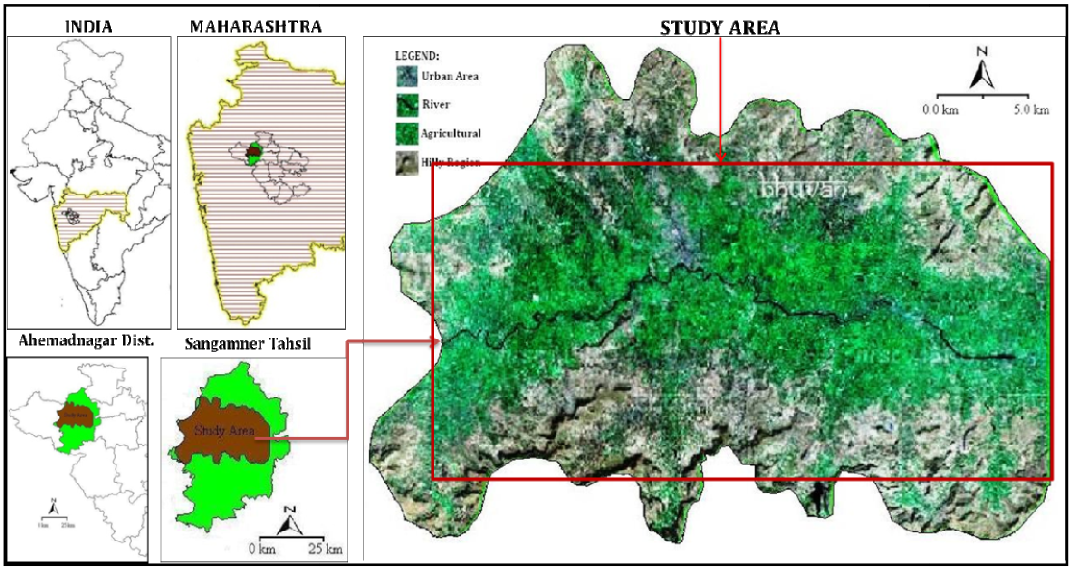


Figure-1
Location map of study area

Material and Methods

For the analysis of particle size of soils field soil survey was carried out with geographical earth coordinates points for 62 soil samples. The surface soil samples (0-20cm) were collected (Fig 2) in cloth bags as per the standard procedure[14,15]. 49 samples are from irrigated and 13 from non-irrigated areas. Quartering technique was used for preparation of soil samples. The samples were dried in air and passed through 2 mm sieve and stored in cloth bags. The textural analysis was done by using International Pipette Method[16,17]. The PSA data obtained is presented in Table 1. The soil classification information related to study area is extracted from soil sheet of Maharashtra using digitization method in GIS software. The textural characteristics information of samples was processed in GIS software using kriging method. Kriging is a geostatistical gridding method that produces visually appealing maps from irregularly spaced data[18]. The Kriging method is based on statistical models that include autocorrelation (the statistical relationship among the measured points)[19]. Geostatistical Analyst uses sample points taken at different locations in a landscape and interpolates a continuous surface. Kriging is an advanced, computationally intensive, geostatistical estimation method that generates an estimated surface from a scattered set of points with z-values[20]. Continues textural analysis maps (Fig.3) of study area were prepared using kinging's smoothing interpolator and default linear variogram function in GIS software.

Results and Discussion

Particle size analysis of soils: The clay content varies from 9.51 to 53.61 %which is shown in Table No. 1. The downstream part and in Ojhar weir area (S1, S2, S3, S4, S5, S8, S9, S10, S12, S14, S15, S16 and S33) belong to predominant clay and clay loam type of soil. This may be due to inadequate drainage and unsuitable geography and siltation at Ojhar weir (figure-1). In addition to this, higher clay content may be owing to the presence of alluvial deposits showing low infiltration. The silt content of the soils varies from 10.8 to 33%. It was also observed that the irrigated and low elevation area (S6, S9, S12, S13, S14 and S16) showed higher silt content. The fine sand and coarse sand ranged from 6.1 to 59.24% and 3.70 to 33.31% respectively. In the downstream part of Ojhar weir (S21, S23, S24, S29, S39, S43 and S60) were noticed with higher content of these sands. However, low values were observed in the part of plain topography, which is characterized by alluvial lithology. Similar results were also obtained by the researchers[21,22] for the soils from the area which is in close vicinity to the present area. This observation is also evidenced by cation exchange capacity values of the study area[11].

The distribution of particle size influences the moisture retention and transmission properties of soils. This is to say that, coarse textured soils have low moisture retention and high permeability whereas fine textured soils have high moisture retention and low permeability[23]. In view of this, it can summarize that the soils which having high clay content (S2, S3, S4, S5, S7, S8, S9, S10, S16 and S20) will show low permeability. The clay fraction contains larger alumino–silicates and has higher content of humus. Therefore, the properties of soils are affected by clay content rather than silt and sand particle. The clay content is also characterized by a higher charge density per unit surface[24]. One of the important factors affecting the chemical properties of soils in the study area may be due to higher proportion of the clay content[11].

Table-1
Particle size analysis of the soils from the study area

Soil Sample	Latitude (Degree decimal)	Longitude (Degree decimal)	Particle size distribution (%)				Soil Class
			Coarse sand	Fine sand	Silt	Clay	
S1	19.5541	74.2542	6.08	24.92	21.6	46.75	Clay
S2	19.5531	74.2605	8.48	29.92	15.35	45.73	Clay
S3	19.5516	74.2651	13.28	28.4	12.2	40.53	Clay
S4	19.5441	74.2664	19.88	13.22	21.1	39.48	Clay loam
S5	19.5477	74.2715	14.32	10.86	25.17	43.93	Clay
S6	19.5465	74.2918	9.48	20.88	32.15	31.98	Clay loam
S7	19.5510	74.2846	18.21	23.12	15	42.18	Clay
S8	19.5541	74.2925	16.52	17.97	22.07	37.43	Clay loam
S9	19.5599	74.2847	7.29	16.17	29.08	41.33	Clay
S10	19.5660	74.2801	28.08	6.07	20.87	39.83	Clay loam
S11	19.5446	74.2993	5.01	14.33	31.15	43.53	Clay
S12	19.5578	74.3138	14.62	25.54	30.15	28.06	Clay loam
S13	19.5618	74.3074	3.52	12.05	26.82	50.23	Clay
S14	19.5511	74.3129	9.51	22.24	26.37	35.68	Clay loam
S15	19.5663	74.2691	31.65	9.81	18.22	37.16	Clay loam
S16	19.5741	74.2775	11.21	27.93	33.3	29.51	Clay loam
S17	19.5750	74.2852	6.57	14.11	21.17	51.03	Clay
S18	19.5290	74.3053	5.48	15.52	26.6	44.93	Clay
S19	19.5368	74.3116	12.45	33.62	15.72	43.18	Clay
S20	19.5429	74.3324	2.15	15.75	23.42	52.33	Clay
S21	19.5305	74.3225	32.68	36.81	13.73	13.51	Sandy loam
S22	19.5255	74.3729	27.67	16.6	19.35	31.71	Sandy clay loam
S23	19.5284	74.3858	15.52	42.76	16.65	20.58	Sandy clay loam
S24	19.5104	74.3464	22.02	42.79	12.42	18.11	Sandy loam
S25	19.5252	74.3596	7.31	16.35	20.12	49.71	Clay
S26	19.5268	74.3455	5.30	15.55	23.35	51.03	Clay
S27	19.5140	74.3302	33.31	27.67	13.35	21.04	Sandy clay loam
S28	19.5053	74.3053	18.25	28.51	19	29.09	Sandy clay loam
S29	19.4801	74.2834	21.26	40.13	14.55	19.38	Sandy loam
S30	19.5146	74.2672	32.78	20.06	12.65	29.26	Sandy clay loam
S31	19.5235	74.2544	17.08	22.62	14.52	39.31	Sandy clay
S32	19.5206	74.2245	6.292	19.91	23.4	42.61	Clay
S33	19.5606	74.2333	7.127	11.35	20.65	53.16	Clay
S34	19.5464	74.2361	3.22	22.71	28.15	37.56	Clay loam
S35	19.5353	74.2518	10.17	19.6	10.67	51.57	Clay
S36	19.5485	74.2201	13.28	33.29	24.4	32.73	Clay loam
S37	19.5376	74.2124	6.647	23.56	15.57	48.06	Clay
S38	19.5548	74.2122	11.67	34.88	21.97	27.03	Clay loam
S39	19.5099	74.1908	25.104	41.25	12.12	17.78	Sandy loam
S40	19.4927	74.1849	19.086	33.56	18.35	22.91	Sandy clay loam
S41	19.5052	74.2058	19.094	31.54	14.27	26.81	Sandy clay loam
S42	19.5405	74.1841	9.935	37.28	23.426	24.61	Sandy clay loam
S43	19.5313	74.1450	7.317	41.96	11.87	33.11	Sandy clay loam
S44	19.5264	74.1279	11.983	32.76	14.87	34.93	Sandy clay loam
S45	19.4914	74.0922	4.143	34.75	11.22	41.56	Sandy clay
S46	19.5116	74.0879	7.559	53.32	22.07	12.28	Sandy loam
S47	19.4721	74.0923	9.139	51.83	16.15	18.01	Sandy loam
S48	19.5369	74.0912	6.592	35.87	20.15	32.11	Sandy clay loam

S49	19.5407	74.1020	12.846	36.87	16.05	28.36	Sandy clay loam
S50	19.5658	74.0983	18.03	45.97	12.95	19.73	Sandy loam
S51	19.5332	74.1176	4.33	19.39	22.52	48.58	Clay
S52	19.5842	74.1336	11.28	50.03	16.93	17.91	Sandy loam
S53	19.5449	74.1392	21.12	41.34	16.1	17.86	Sandy loam
S54	19.5481	74.1718	10.372	26.884	18.12	40.36	Clay loam
S55	19.5494	74.1511	3.696	29.51	23.87	38.68	Clay loam
S56	19.5620	74.1905	6.117	33.33	20.27	33.68	Clay loam
S57	19.5911	74.1744	4.23	31.55	12.37	45.26	Clay
S58	19.5845	74.2141	2.199	28.66	13.75	46.93	Clay
S59	19.6039	74.2422	4.777	28.35	10.87	46.56	Clay
S60	19.5837	74.3153	19.932	49.24	7.875	19.51	Sandy loam
S61	19.5739	74.3145	11.266	34.59	10.8	35.51	Sandy clay
S62	19.5665	74.3679	6.595	29.1515	12.2	44.56	Clay

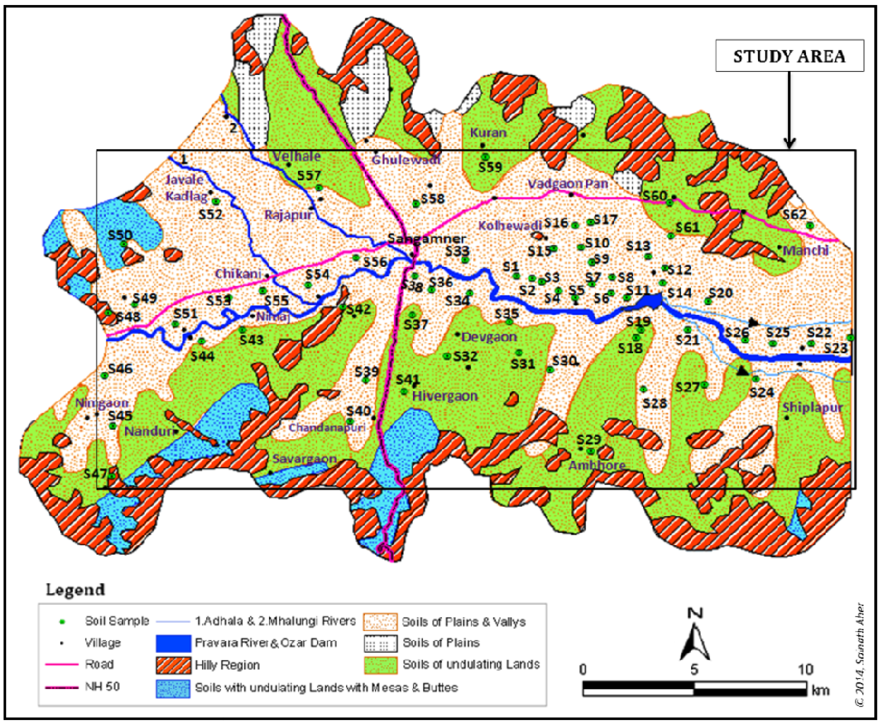
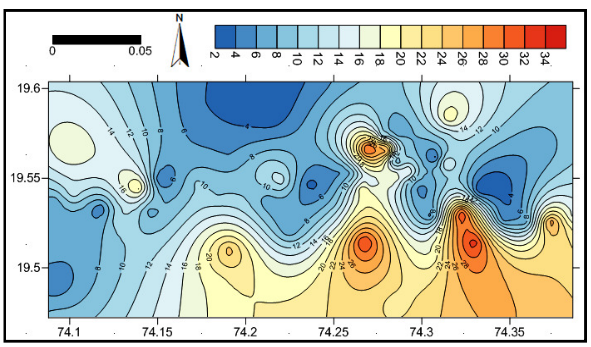


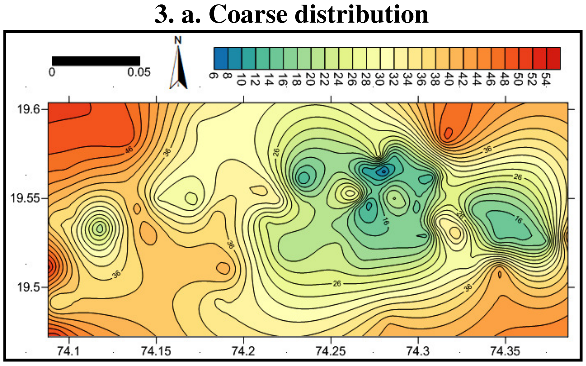
Figure 2
Types of soils and sampling points in the study area

GIS mapping of the soils: Soil classification information related to study area was extracted from soil sheet of Maharashtra (Sheet No. 1, scale: 1:50000). It has published in 1996 by Survey of India (SOI)[25]. This soil sheet was Georeferanced in GIS software for the accurate prediction of soil particle. Georefrancing is needed for the correction of geometrically distorted image in applied form. The process of Georefrancing is to transfers the distorted image co-ordinates to the specific map projection. This could be thought of as involving recovering the correct geometry and image to map registration i.e. transforming the image coordinates system to a particular map coordinates system[26]. GIS is the powerful tool, which offer to the data storing, manipulation, management displaying functions within minimum time. Therefore, any spatial mapping, data analysis and base map preparation at precise level became calmer due to GIS environment[27]. From the soil sheet information soil of plains and valley is observed around the Pravara River banks, which has high deepness due to river flood plain. Maximum samples of soils were collected from these plains and valley types of clay soils, which show the high salinity. The soils of undulating land belts slightly away from river bank; shows slightly deepness and moderate textural structure. The soils of plains is generally loamy soils on gently sloping plain with moderate erosion, which is located in the northern part of area at the eastern slope of hilly region. The soils of undulating lands with mesas and buttes observed the low water holding capacity due to courses and nature, which showed low salinity and sodicity (figure-2).

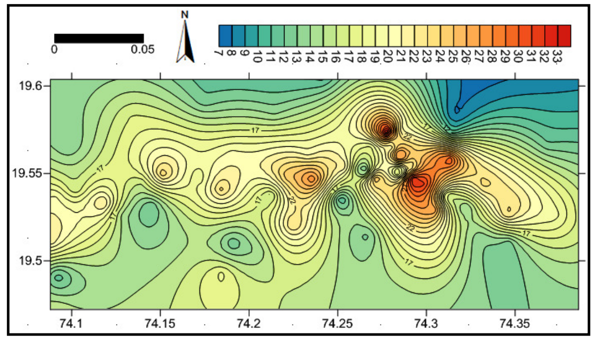
Interpolation of Particle size analysis: Particle size analysis (PSA) of soils obtained only at a few locations for a given area and therefore, requires some form of interpolation or spatial prediction. In order to meet these requirements in the study applied interpolation techniques using kriging method[28]. Interpolation is used to convert data from point observations to continuous fields so that the spatial patterns sampled by these measurements can be compared with spatial patterns of other spatial entities[9]. In the present study, interpolations of 62 soil samples from the study area were performed for preparation of textural distribution maps (figure-3). The soil sample points textural classification data are interpolated to produce ordinary soil textural classification zones of study area. The Kriging method was employed to compare the performances for interpolating particle size analysis. In kriging, spherical, exponential and Gaussian models were fitted using the variogram. Once the variogram is known, the value of an attribute at any point in a mapping unit can be predicted from the available data points using kriging[29]. The maximum distribution of clay particle (figure-3d) located at the downstream part, whereas silt particle (figure-3c) at the middle part of study area which is in agreement with the experimental findings. Similarly, the distribution of coarse particle (figure-3a) located in the southern part and fine distribution (figure-3b) in the western part of the study area.



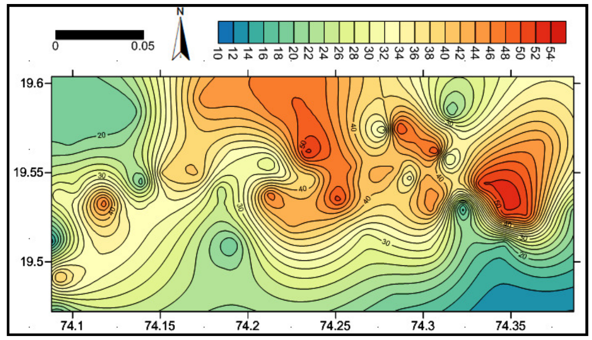
3. a. Coarse distribution



3.b. Fine distribution



3. c. Silt distribution



3.d. Clay distribution

Figure-3

Spatial Interpolated maps of textural distribution in study area

Conclusion

The PSA of 62 soil samples were carried out by using International Pipette Method. The five textural groups of soils viz. clay, clay loam, sandy loam, sandy clay loam and sandy clay were identified in the area. Out of these, majority of the samples represent clay (35.48 %) and clay loam (22.58 %) type, which are located in the downstream part of the river. This is due to adequate drainage conditions in the study area. The remaining textural groups observed are sandy clay loam (21 %), sandy loam (16 %) and sandy clay (5 %). This textural distribution prediction also carried out by GIS interpolation technique. The process of interpolation of soil textural characteristic and soil types digitization helped for continuous textural information generation at precise level. The superimposing of soil samples over soil types clearly visualized the relationship between soil types and texture. GIS techniques hence after referred as GIS is found to be best suited for the quantification of the soils textural characteristic and its modeling in the study area. Hence, both the study of soil textural characteristics and its interpolation at higher precision will helpful for the textural management concerns all operations, practices and treatments used to protect soil and enhance its performance.

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