International Journal of Agricultural Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 9, Issue 2, Apr 2019, 1-8

SOIL MAPPING OF PATIALA-KI-RAO WATERSHED IN SHIVALIK FOOT-HILLS USING GIS

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ABSTRACT

Soil is the upper layer of earth and shows adaptable physical, chemical and hydrological properties. The particle size of any soil is an important part of soil and sediment characterization of the watershed. The soil textural distribution information in a watershed is important for soil characteristics determination, agriculture crop production, irrigation planning and management of soil resources. However, soil texture information acquired through manual field survey and particle size analysis is expensive and time consuming. Considering this study was carried out to know the particle size characteristics of Patiala-Ki-Rao watershed in Shivalik Foot-hills of Punjab. Particle size analysis was determined from 50 soil samples and interpolated in Geographic Information System (GIS) software using Inverse Distance Weighing (IDW) method. It gives the micro level particle size information at accurate scale. This information will helpful for proper soil management and sustainable livelihood of the inhabitants in the watershed.

***KEYWORDS:** GIS, IDW Method, Interpolation & Patiala-Ki-Rao Watershed*

Received: Nov 16, 2018; **Accepted:** Dec 06, 2018; **Published:** Feb 04, 2019; **Paper Id.:** IJASRAPR20191

Original Article

INTRODUCTION

Soil is the modifier of the earth's environment and integration of pedosphere which interfaces with the lithosphere, hydrosphere, atmosphere, and biosphere. Soil is a product of the influence of climate, relief, organisms and original materials interacting over time. Soil texture is the important property of soil and is defined as the relative proportions of clay, sand and silt contents. Physical, mechanical and hydraulic properties of the soil have significantinfluence by the soil texture (Marc *et al* 2011). Soil fertility is the interaction of soil clay with nutrient ions, water and organic substances and it is significantly controlled by the quality and nature of minerals (Thompson and Troen 1973). Soil texture has agricultural operation such as determining crop suitability and to predict the response of the soil to environmental and management conditions. Water-retention, flow characteristics and rate of water intake can determine by soil texture which, directly affects the porosity of soil. Soil texture predicts the hazard of soil erosion by determining its soil erodibility. Land use capability and soil management practices are also determined by the texture (Zhengyong*et al* 2008).

Soil mapping of watersheds is crucial in *Shivalik*foot-hills, locally known as *kandi* area. The *Shivalik*foot-hills are a part of the Himalayan mountain chain which continuously runs from Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana and finally end up at Bhabbar tracts of Garhwal and Kumaon in Uttarakhand. The *Shivalik* foot-hills are facing serious problems of soil erosion, land degradation and sedimentation which are reducing agricultural productivities (Bhardwaj and Kaushal 2009). Patiala-Ki-Rao watershed which is located in the *Shivalik*foot-hills of Punjab is facing similar problems. Therefore, soil mapping of Patiala-Ki-Rao watershed should be studied to predict the soil erosion (Kushwaha *et al* 2016, Singh *et al* 2016).

Soil texture is determined by the Particle size analysis. It is expressed in classes of which the relative properties can be summed up in the form of a triangular diagram enabling the texture of a soil sample. However, soil texture information acquired through manual field survey and particle size analysis is expensive and time consuming. Mapping soil texture by spatial distribution at regional scale can eliminate this limitation (Deshmukh *et al* 2014). Spatial distribution is the arrangement of a phenomenon across the Earth's surface and graphical representation of such arrangement. It is an important tool in geographical and environmental studies. It is a useful tool for soil characteristic property interpolation in precision agriculture and soil management (Minasny and McBratney 2007). Geographical Information System (GIS) in association with particle size information is useful in mapping of soil properties and provides a suitable platform for data update, analysis and recovery in less time and cost and with improved precision (Reddy 2006). Many researchers have studied the soil textural characteristic and its interpolation using GIS techniques (Chall*et al* 2000, Christos *et al* 2009, Deshmukh *et al* 2014). Hence, in this study Particle size analysis of soils was done and interpolated by using GIS technique.

MATERIAL AND METHODS

Description of Study Area

Patiala-ki-Rao watershed having an area around 5140 ha, which was affected by the urbanization over the last two decades, has been selected as the study watershed. It is located adjoining the city of Chandigarh between the coordinates of 30º 45'27.53" N, 76º 44'44.03" E and 30º 49'54.40" N, 76º 52'24.86" E in the *Shivalik* foot-hills of Punjab as shown in Figure 1. The watershed has a sub-humid type of climate. An average annual rainfall in the watershed is recorded as 910 mm, out of which around 80% rainfall is received during monsoon months from June to September. The soils are generally shallow in the *Shivalik* foot-hills. The major physiographic units in the study are watershed in *Shivalik* foot-hills, piedmont plain and seasonal rivulets locally known as *Choes*. The land surface of the watershed is mainly covered with forest, grass lands, fallow land, agriculture and built-up.

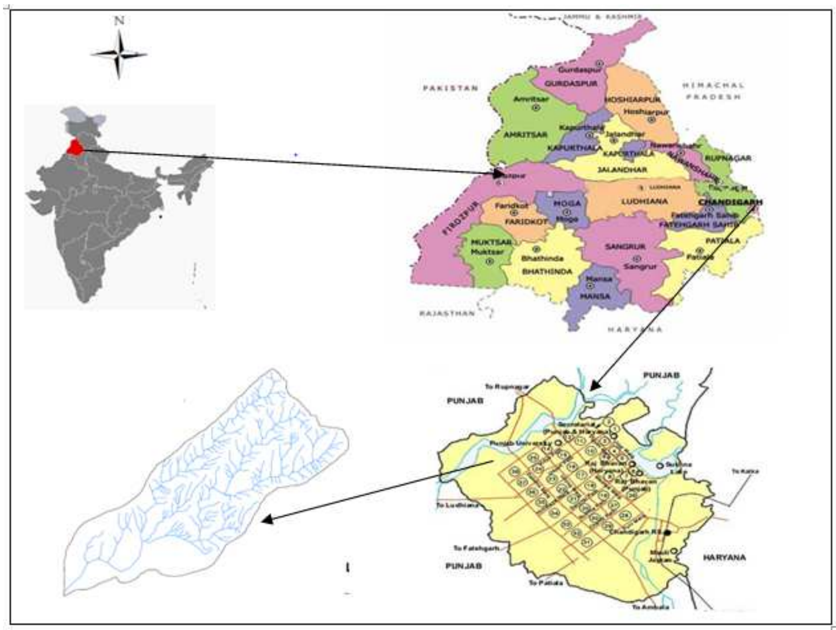

Figure 1: Location Map of the Study Watershed at Patiala-Ki-Rao in Punjab

Data Used

Survey of India (SOI) toposheet no 53 B/9 on 1:50000 scale is used to delineate the watershed. 50 soil samples were taken by using random sampling and analysed in the laboratory for particle size distribution to determine soil texture.

Digitization of Watershed

Study watershed was delineated from SOI toposheet no 53 B/9 on scale 1:50000. The watershed boundaries were drawn on tracing paper from characteristics of contour lines. The traced watershed is scanned and added into the GIS environment. The scanned image was then Georeferenced by assigning real-world coordinates for different points obtained from the toposheet by using UTM projection and WGS 84 datum. Then, features from the traced map were digitized by on-screen digitization in polygon format.

Particle Size Analysis of Soils

The particle size distribution of the 50 uniformly distributed soil samples taken from top 30 cm soil layer at different locations in the watershed (Figure 2.) The surface soil samples were collected as per the standard procedure samples. The samples were dried in the air and passed through a 2 mm sieve and stored in cloth bags. The textural analysis was done by using International Pipette Method (Gupta 2009).

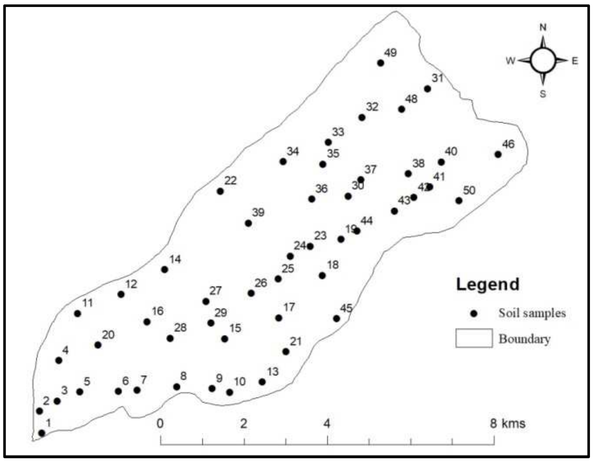

Figure 2: Location of Soil Samples in the Watershed

Interpolation of Data

Particle size analysis of soils obtained only at a few locations for a given area and therefore, requires some form of interpolation or spatial prediction. 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 (Christos *et al* 2009). In the present study, interpolations of 50 soil samples from the study area were performed for preparation of textural distribution maps. The characteristics information of samples was processed in GIS software and interpolated using three methods: Kriging, Inverse Distance Weighing (IDW) and Cubic Spline method. Kriging method is a gridding method that produces visually appealing maps from irregularly spaced data (Sakata *et al* 2004). IDW method is a type of deterministic method for multivariate interpolation with a known set of points. The assigned unknown points are calculated with a weighted average of the known points. The cubic spline method creates the splines by fitting the input points with a piecewise cubic polynomial curve that passes through every known point. In the interpolation process, particle size analysis data were added into the GIS environment. The digitized watershed is also added. Then the data was interpolated using spatial analyst tools. Spatial analyst tools use the known location data and determine the data of unknown locations using above three methods. After the interpolation, the maps are presented with different colour compositions for further analysing.

RESULTS AND DISCUSSIONS

Particle Size Analysis of Soils

The sand content ranged from 36.52 to 69.89% as shown in Table 1. The soil samples taken near stream banks (S1, S4, S11, S12, S14, S21, S24, S25, S28, S29, S34, S36, S38, S40, S44 and S49) were noticed with higher content sands. However, low values were observed in the part of the plain topography forest area. The clay content varies from 14.24 to 36.42 %. The downstream part of watershed area (S8, S9, S15, S17, S19, S20, S22, S23, S27, S31, S32, S37 and S39) belong to the predominant clay loam type of soil. This may be due toundisturbed forest area. The silt content of the soils varies from 3.05 to 41.17%. It was also observed that the irrigated and low elevation area (S2, S3, S6, S7, S10, S13, S16, S18 and S33) showed higher silt content.

Table 1: Particle Size Analysis of Soils from the Watershed

Sample No.	Latitude	Longitude	Sand (%)	Clay (%)	Silt (%)	Texture
S1	30.7623	76.7526	69.89	17.77	12.34	sandy loam
S2	30.7671	76.7521	49.66	20.66	29.68	loam
S3	30.7692	76.7566	48.23	21.23	30.54	loam
S4	30.7780	76.7571	67.19	17.84	14.97	sandy loam
S5	30.7711	76.7623	60.45	28.88	10.67	sandy clay loam
S6	30.7711	76.7720	46.88	20.22	32.9	loam
S7	30.7713	76.7766	45.2	20.65	34.15	loam
S8	30.7719	76.7866	49.53	27.59	22.88	clay loam
S9	30.7714	76.7955	64.56	26.66	8.78	sandy clay loam
S10	30.7706	76.7999	48.64	21.81	29.55	loam
S11	30.7881	76.7621	68.44	15.55	16.01	sandy loam
S12	30.7921	76.7730	67.66	15.23	17.11	sandy loam
S13	30.7726	76.8081	36.52	22.31	41.17	loam
S14	30.7973	76.7841	67.23	17.85	14.92	sandy loam
S15	30.7821	76.7989	53.64	36.42	9.94	sandy clay loam
S16	30.7861	76.7795	38.95	29.64	31.41	clay loam
S17	30.7865	76.8125	53.66	34.44	11.9	sandy clay loam
S18	30.7955	76.8236	48.23	20.82	30.95	loam
S19	30.8033	76.8284	49.84	28.11	22.05	clay loam
S20	30.7812	76.7671	54.12	33.55	12.33	sandy clay loam
S21	30.7791	76.8142	68.23	15.43	16.34	sandy loam
S22	30.8141	76.7984	58.11	27.73	14.16	clay loam
S23	30.8019	76.8207	55.12	34.44	10.44	sandy clay loam
S24	30.7998	76.8156	69.45	17.11	13.44	sandy loam
S25	30.7949	76.8125	68.87	28.08	3.05	sandy clay loam
S26	30.7919	76.8056	64.66	24.44	10.9	sandy clay loam
S27	30.7903	76.7943	49.56	28.46	21.98	clay loam
S28	30.7824	76.7852	68.32	29.01	2.67	sandy clay loam
S29	30.7856	76.7954	67.55	15.26	17.19	sandy loam
S30	30.8126	76.8304	48.85	26.78	24.37	clay loam
S31	30.8356	76.8508	56.12	35.32	8.56	sandy clay loam
S32	30.8296	76.8342	48.23	29.56	22.21	clay loam
S33	30.8243	76.8256	48.56	21.23	30.21	loam
S34	30.8203	76.8142	68.23	15.23	16.54	sandy loam

Table 1: Contd.,

S35	30.8196	76.8242	47.98	28.64	23.38	clay loam
S36	30.8121	76.8212	68.23	15.12	16.65	sandy loam
S37	30.8161	76.8336	48.56	29.56	21.88	clay loam
S38	30.8172	76.8456	66.56	23.44	10	sandy clay loam
S39	30.8071	76.8052	49.33	29.54	21.13	clay loam
S40	30.8197	76.8539	67.23	14.88	17.89	sandy loam
S41	30.8143	76.8509	66.32	24.56	9.12	sandy clay loam
S42	30.8121	76.8469	56.43	25.56	18.01	clay loam
S43	30.8092	76.8419	65.56	26.54	7.9	sandy clay loam
S44	30.8050	76.8324	69.56	15.36	15.08	sandy loam
S45	30.7861	76.8270	68.32	15.16	16.52	sandy loam
S46	30.8211	76.8682	67.56	15.08	17.36	sandy loam
S47	30.8270	70.8612	64.23	25.59	10.18	sandy clay loam
S48	30.8312	76.8441	55.59	25.35	19.06	clay loam
S49	30.8413	76.8391	69.64	14.42	15.94	sandy loam
S50	30.8112	76.8582	69.42	14.24	16.34	sandy loam

Interpolation of Particle Size Analysis

In the present study, interpolations of 50 soil samples from the study area were performed for preparation of textural distribution maps. Out of three methods, IDW method gave accurate results along the area of the watershed. Distribution of sand particles in the watershed is shown in Figure 3. Sand content is maximum (63 – 70%) in fallow lands where there is no irrigation. Sand content is minimum(37 – 50%) in agriculture lands due to adequate irrigation facilities. Distribution of clay particles in the watershed is shown in Figure 4. Clay content is maximum (32 – 36%) in grass and forest lands due to inadequate drainage facilities. Clay content is minimum (14 – 19%) in built-up lands. Distribution of silt particles in the watershed is shown in Figure 5. Silt content is maximum (33 – 41%) in the banks of streams where excess eroded particles are stored and over irrigated agriculture lands. Silt content is minimum (3 – 18 %) in undisturbed forest lands and built-up lands.

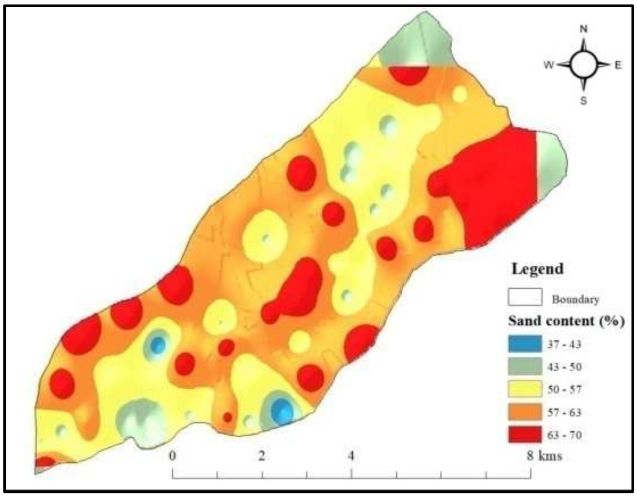

Figure 3: Sand Distribution in Watershed

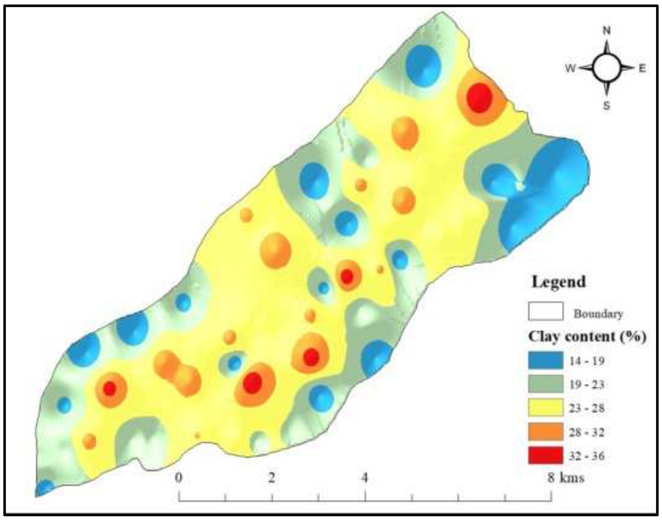

Figure 4: Clay Distribution in Watershed

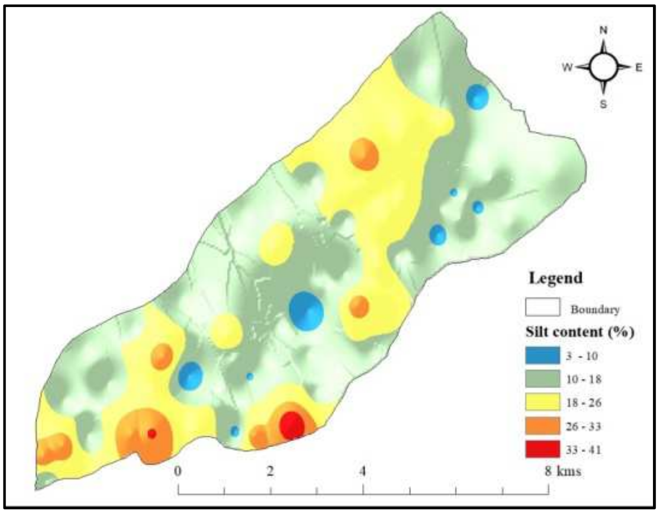

Figure 5: Silt Distribution in Watershed

CONCLUSIONS

The 50 soil samples which are determined by using International Pipette Method were analysed against particle size distribution. Clay loam, sandy loam, sandy clay loam and loam type textural classes were identified in the area. The majority of the samples collected along the length of stream represented sandy loam (32%) and sandy clay loam (28%) type. The remaining textural groups observed are clay loam (24 %) and loam (16 %). This textural distribution was interpolated in GIS environment using interpolation techniques. For the generation of continuous textural information at a precise level, the process of interpolation of soil textural characteristics is essential. Among GIS interpolation techniques, IDW methodis found to be best suited for the quantification of the soil textural characteristics in the study area. Hence, both the study of soil textural characteristics and its interpolation will helpful for conservation and management of soil in the watershed area.

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