Original Research Article

Characterization and Study of Dominated Alluvial Soil Profile of Mirzapur in Indo-Gangetic Plain (IGPs) of India

Abstracts

This provides the basic information necessary to create functional soil classification schemes and assess soil fertility in order to unravel some unique soil problems in an ecosystem. The coupling of soil characterization, soil classification and soil mapping provides a powerful resource for the benefit of mankind especially in the area of food security and environmental sustainability. Among the cationic micronutrients, Zn content varied between 1-3 ppm in the Mirzapur soil profile. Copper content varied between 1-7 ppm in Jamalpur, 1-4 ppm in Narayanpur. The available Cu content is categorized as sufficient if it is > 0.2 ppm. Available iron content varied between 2-40 ppm in Jamalpur soil profile and 8-63 ppm in the Narayanpur soil profile. Available Mn content varied between 2-40 ppm in Jamalpur, 5-18 ppm in Narayanpur. Soils are generally categorized as having enough manganese in the DTPA extractable Mn content is > 0.2 ppm. Hence all soils of Jamalpur and Narayanpur had sufficient available soil manganese.

Keywords- Soil profile; **S**oil fertility, soil characterization, soil classification, environmental sustainability

1. Introduction

There is an increasing demand for information on soils as a means to produce food (Fasina *et al.*, 2007). Agriculture is the predominant economic activity in India and because of agricultural development and increasing demand in India, much work is carried out on soil characterization. This provides the basic information necessary to create functional soil classification schemes, and assess soil fertility in order to unravel some unique soil problems in an ecosystem (Lekwa *et al.*, 2004). The coupling of soil characterization, soil classification and soil mapping provides a powerful resource for the benefit of mankind especially in the area of food security and environmental sustainability. Soil use refers to the conversion of a whole or a part of the soil for specific purposes like agricultural activities, house building, or industry purposes etc. (Rai, 2015). It also provides adequate information in terms of landform, natural vegetation as well as characteristics of soils which can be utilized for land resources management and development (Manchanda *et al.* 2002). The alluvium deposit of both old and new types by the two great rivers of India, the Ganga and the Yamuna are found in this region, only the southern uplands, touching the Vindhya hills are not covered by such deposits. Sandstone, shale, conglomerate and limestone are found in the SunValley region of Mirzapur. The sands of the Kaimur group are of two to three-metre thick friable sandstone. The silica sand found in Chandauli district is fine to medium-grained, brown and buff in colour. Most of the glass factories of northern India get their supply from this region. Similar sands are reported from Robertsganj plateau of Mirzapur district. Besides kankar, which is found in abundance in various parts of the study area, suitable limestone occurs in some places of Mirzapur district (Agarwal, *et al.*, 1952). The rivers rising from the mountains during the period of great gradational activity deposited the detritus brought down by them in their long journey and in this way the plain was formed (Wadia, 1975). The sediments deposited at the bed of the Tethys Sea was folded and warped due to the northward drift of peninsula (Khullar, 2005). This rolling upland, touching the Vindhya hills exhibits a complex and heterogeneous nature of topography with detached hills, flat-topped ridges, summit plains and entrenched narrow as well as broad valleys almost reaching the base level. In the eastern part, the east-west trending Vindhayan range composed of shallow marine deposits of proterozoic age, divides the Ganga plain in the north and vast pediplain exposing metamorphosed sequence of Archaean age in the south (NATMO, 2008). Based on the micro-level topographic facets, the Ganga plain can be divided into three sub-regions, viz. (i) the older alluvium or *Bhangar*; (ii) the newer alluvium or khaddar and (iii) the *terai*adjoining to the bhabar area is the terai. Geologically Eastern Uttar Pradesh is made up of diverse rock types, ranging in age from the oldest.

Owing to the fact that Mirzapur district is an agrarian community outskirt and not much study has been done on the soils of the area, characterization and classification will help reveal information that could be useful in the management and use of the soils on a sustainable manner. The objective of this research therefore, is to characterize and classify the soils of Mirzapur District of Utter Pradesh.

2. Material and methods

2.1. Study area

Mirzapur district is situated in the southern part of Uttar Pradesh and is located between 25.8° N to 25.15° N latitude and 82.34° E to 82.58° E longitude covering an area of 4952.5 km^2. The soils of the study region comprised of alluvial soil representing entisol and soils which are formed on granitic parent material representing Alfisols.

2.2. Method of soil collection and preparation

A total of five profiles were dug and samples were collected from each location. To collect a soil sample, surface litter was gently scraped off with a khurpi. A rectangular pit was dug to a depth of 1m x1 m x 1m. Soil samples were collected from the wall of the rectangular pit using stainless steel auger from a depth of 0-5, 5-15, 15-30, 30-60 and 60-100 cm. In addition, to measure the bulk density, core samplers having cores measuring 5 cm in length and 5 cm in diameter were used. Soil samples were dried in shade and brought to the laboratory where they were ground to pass through 2 mm sieve, tagged and stored in plastic containers for analysis.

2.3. Analysis of samples

The bulk density was estimated using the soil core sampler method (Blake, 1965). Soil colour was measured using a Munsell's soil colour chart. For this air-dried soil was taken on plastic sheets and the colour matched with the colour notation of the chart. The Munsell system divides colour into hue; value; and chroma. Hue is the wavelength of the colour, value is the tone (from dark to light), and chroma is the colour saturation. The Pycnometer method was used to estimate the particle density of soil using water as the displacing liquid as the soils were salt free and non-swelling type. The water holding capacity (WHC) of the soils was measured in the laboratory using keen- Rackzowski box (Black, 1965). Particle size analyses of soils were estimated by hydrometer method as described by Bouyoucous (1927). The soil pH and electrical conductivity (EC) were recorded in 1:2.5 soil to water suspension (Jackson, 1973). Exchangeable bases were collected using neutral normal ammonium acetate and the exchanged ion measured following the procedure outlined in Hesse (1970). The total Ca^{++} and Mg^{++} was determined by complexometric titration, involving ethylene diamine tetra acetic acid (EDTA). Different soil chemical properties determined were: soil organic carbon (OC) content by chromic acid wet oxidation method (Walkley and Black, 1934), Carbon stocks were determined using the formula,

$$CarbonStock = \frac{TOC \times BD \times D \times 10{,}00}{100}$$

Where Carbon Stock is $Mgha^{-1}$, TOC is the Total organic carbon expressed as Mg 100 Mg^{-1}, BD id bulk density in Mgm^{-3} and D is the depth of soil in m.

Available nitrogen (N) was estimatedby alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus (P) spectrophotometrically (Olsen *et al.,* 1954), available potassium (K) by flame photometrically (Hanway and Heidel, 1952), soil available micronutrients iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) by DTPA-extraction method (Lindsay and Norwell, 1978). Water-soluble ions were determined in 1:2.5 soil to water suspension, whereas, exchangeable ions in neutral normal ammonium acetate extract (Richards, 1954). The data on soil properties were correlated with the Pearson Correlation analysis by colour matrix using R square (R version 3.5.1) to signify the relationship among different soil parameter at different depths.

3. Results and Discussions

3.1. Physical properties of young alluvial soil

The young alluvial soil of Mirzapur is found in the northern part of the district adjoining the Ganga basin. Soil profile from three locations namely Mirzapur, Chunar, and Chhanbey block was studied to represent and cover the entire stretch of young alluvial soil. The physical properties of young alluvial soil are presented in Table 1 and 2 and the profile photograph of the three profiles presented in figure1 to 3

There was no variation in soil colour observed at all soil depths in the Chhanbey soil profile. But the Chunar soil profile exhibited a red colour in the plough layer and become yellow-red at lower soil depths. Red, yellow and brown colour is related to the extent of oxidation, hydration and diffusion of iron oxides in the soil. Yellow, red and brown colours are mostly due to the presence of goethite, hematite and magnetite respectively. Organic matter in soil tends to impart dark brown to black colour. So for as texture is concerned, coarse-textured soils are usually light in colour whereas well-textured soil appears darker in colour (Phogat*et al.,* 2015).

Bulk density is the weight of soil in a given volume and is an indicator of ease of root growth. Bulk densities higher than 1.6 g cm^{-3} generally cause restrict root growth. Bulk density increases with compaction and trends to increase with depth. Sandy soil was prone to more bulk density. The bulk density of Mirzapur profile varied between 1.49 and 1.94 Mg m^{-3} and is considered to be quite compact. Higher bulk densities are observed at lower soil depths.

Porosity is generally lower in coarse-textured soil than in fine-textured soil. The porosity of profile soil samples of Mirzapur varied from 26.7 to 43.7 (average 34.9 %) and the corresponding value for Chunar and Chhanbey varied from 30.5 to 56.7 % (mean 42.06 %) and 30.4 – 43.6 % (mean 34.7%) respectively. Thus the overall porosity of young alluvial soils varied from 26.7 – 56.6 % (mean 38.4) which is representative of normal soils. The porosity was always higher near the surface soil layers and decreased with increased soil depth.

The water holding capacity did not vary much among profiles of young alluvial soils.The overall variation in the young alluvial soil profiles of Mirzapur district ranged from 40.5 – 44. 4 % (average 42.70%).

It was found that the content of clay varied from 29-43% in Mirzapur profile, 27-45% in profile soils of Chunar and 32-42% in profile soil of Chhanbey with an overall range between 27-45% in young alluvial soils. The silt content varies from 29-45% in Mirzapur, 30-43 % in Chunar and 20-48% in Chhanbey; the overall silt content varying between 29 and 48%. The overall sand content varied from 12-42 % in these soils. The textural class varied between loam to clay loam in Mirzapur, clay to clay loam in Chunar and silty clay loam to clay loam in Chhanbey.

3.2 Physical properties of old alluvial soils

The old alluvial soils were located in the northeastern part of the district of Mirzapur. Soil profile from two locations namely Jamalpur and Narayanpur were studied to represent old alluvial soil. The physical properties of old alluvial soil have been presented in (Table 3 and 4) and a profile photograph of the two profiles presented in figure 4 and 5.

The Jamalpur soil profile (Figure 4) varied in colour between 5Y8/2 and 2.5Y 8/2, Yellow colour indicates the presences of ferric iron oxide. The surface soil at Jamalpur was different in colour from the rest of the profile, which had a lighter colour. In Narayanpur, the soil in the plough layer (0-15 cm) was uniform in colour (5Y8/1) and the soils at lower depth (15-60 cm) were a shade darker in chroma than the surface soils. The profile photograph of Narayanpur has been depicted in figure 6 which clearly show accumulation of organic matter in soil profile.

The bulk density of Jamalpur profile varied between 1.52 and 1.70 Mg m^{-3} and is considered to be quite compact. Higher bulk densities were observed at lower soil depths. Thus the overall porosity of old alluvial soil varied from 34.32 – 42.51 % (mean 37.63) which is representative of normal soils. The water holding capacity did not vary much among profiles of old alluvial soils and varied from 42.70 to 45.50 % (mean 44.16 %).

It was found that the content of clay varied from 17 to 27 % in Jamalpur profile and 16 to 22 % in profile soils of Narayanpur with an overall range between 16-27 % in old alluvial soils. The silt content varied from 40 to 56% in Jamalpur and 36 to 42 % in Narayanpur; the overall silt content varied between 36 to 56 %. The overall sand content varied from 17 to 43 % in the old alluvial soil profiles. The texture was loam in both Jamalpur and Narayanpur.

3.3 Physico-chemical properties of young alluvial soils.

Three soil profiles were studied to represent young alluvial soils of Mirzapur district, namely Mirzapur, Chunar and Chhanbey (Table 1 and 2) The overall trend in pH of young alluvial soils showed slightly acidic (pH 6.4) to alkaline (pH 9.1) soil reaction.The overall EC in the young alluvial soils of Mirzapur ranged from 0-12 to 0.55 dS m^{-1}, which is non-saline. Hence there is no warning on the growth of all types of crops in these soils.

The organic carbon status of the surface soil layer (0-5cm) was also medium in the category and decreased to the low category with the increase in soil depth. Thus, the young alluvial soils are sufficient in the surface soil layer, but are deficient in the lower soil depths. The decrease in organic carbon with depth has previously been reported by different workers. Bhatnagar*et al.* (2003) reported higher amounts of organic carbon in surface than in subsurface soils as a result of it’s recycling, over the years by plants and subsequent organic matter accumulation.The exchangeable Ca content in Mirzapur profile varied between 3.25 and 4.8 Cmol (+) kg^{-1}, whereas, the Mg content varied between 3.45 to 7.3 Cmol(+) kg^{-1}. There was enough calcium and magnesium content in the soil to support plant growth.

3.4 Physico-chemical properties of old alluvial soils.

Two soil profiles were studied to represent old alluvial soils of Mirzapur district, namely Jamalpur, and Narayanpur (Table 3 and 4). The overall trend in pH of old alluvial soils was that they were very slightly acidic (pH 6.2) to alkaline (pH 8.6) in reaction. The overall EC in the old alluvial soils of Mirzapur ranged from 0.04 to 0.44 dS m^{-1}, which is non-saline. Hence there is no warning on the growth of all types of crops in these soils. The profile samples of Jamalpur had low soil organic carbon content. The values were 0.33 % in the surface soils and decreased to 0.1% at 60-100 cm depth. Exchangeable calcium and magnesium were extracted using neutral normal ammonium acetate and measured by EDTA titration. The exchangeable Ca content in Jamalpurprofile varied between 5.25 to 7.50 C mol (+) kg^{-1}, whereas, the Mg content varied between 3.00 to 3.45 C mol(+) kg^{-1}. There was enough calcium and magnesium content in the soil to support plant growth. The exchangeable Ca content in Narayanpur varied between 2.75 to 5.00 C mol (+) kg^{-1}, whereas the magnesium content varied between 3.90 to 6.85 C mol (+) kg^{-1}.

3.5 Available nutrient status of young alluvial soils.

The available N content in Mirzapur profile (Table 1 and 2) varied from 147-235 kg ha^{-1} with the mean value of 204 kg ha^{-1}, which can be categorized as low (<280 kg ha^{-1}). The highest available N content was observed at 0-5cm (235kg ha^{-1}) and lowest at 60-100cm (147 kg ha^{-1}) depth**.** The available N content in the soil profile of Chunar was similar to Mirzapur and varied between 201 and 267 kg ha^{-1}, with a mean value of 236 kg ha^{-1}, which is categorized in the low category of available N. The available N content in Chhanbey varied between 78 and 191 kg ha^{-1} (mean 144 kg ha^{-1}), which is even lower. Thus, the new alluvial soils have available N in the range of 78-267 kg ha^{-1} and all soils had low available N status.The available P content in soil profiles of Mirzapur varied from 8-16 kg ha^{-1} with the mean value of 11 kg ha^{-1}, which falls under the low to medium category. Medium category of available P was noticed at 0-5 cm depth (16 kg ha^{-1}) and the lowest value at 60-100cm (8 kg ha^{-1}) depth. Available potassium content in soils of Mirzapur profile varied between 138-219 kg ha^{-1} with mean value 186 kg ha^{-1}. The highest available K was noticed at 0-5 cm (219 kg ha^{-1}) and the lowest value at 60-100 cm (138 kg ha^{-1}) depth of soil profile.Among the cationic micronutrients, Zn content varied between 0-2 ppm in the Mirzapur soil profile, 2-9 ppm in the Chunar soil profile and 1-2 ppm in the Chhanbey soil profile.The copper content in soil profile varied between 0-11 ppm in Mirzapur, 2-9 ppm in Chunar and 0-3 ppm in Chhanbey.Available iron content varied between 12-29 ppm in Mirzapur soil profile, 2-11 ppm in the Chunar soil profile and 13-70 ppm in the Chhanbey soil profile. Soils are generally categorized as having sufficient iron if the DTPA extractable Fe content is > 4.5 ppm.AvailableMn content in soil profiles varied between 3-27 ppm in Mirzapur, 9-25 ppm in Chunar and 3-26 ppm in Chhanbey.

3.6 Available nutrient status of old alluvial soils.

The available N content in soil profiles of Jamalpur (Table 4) varied from 34 to 154 kg ha^{-1} with a mean value of 102 kg ha^{-1}, which can be categorized as low (<280 kg ha^{-1}). The highest available N content was observed at 0-5cm (151kg ha^{-1}) and lowest at 60-100cm (34kg ha^{-1}) depth**.** The available N content in the Narayanpur soil profile was similar to Jamalpur and varied between 69 to 220 kg ha^{-1}, with a mean value of 157 kg ha^{-1}, which was also low in available N. The available P content in soil profiles of Jamalpur varied from 7-11 kg ha^{-1} with the mean value of 9 kg ha^{-1}, which falls under the low category. Medium category of available P was noticed at 0-5 cm depth (11 kg ha^{-1}) and the lowest value at 60-100cm (7 kg ha^{-1}) depth.Available potassium content in Jamalpur soil profile varied between 173 -299 kg ha^{-1} with mean value 244 kg ha^{-1}. The highest value was noticed at 5-15 cm (299 kg ha^{-1}) and the lowest value at 60-100 cm (173 kg ha^{-1}) depth of soil profile.Among the cationic micronutrients, Zn content varied between 1-3 ppm in the Mirzapur soil profile.Copper content varied between 1-7 ppm in Jamalpur, 1-4 ppm in Narayanpur. The available Cu content is categorized as sufficient if it is > 0.2 ppm.Available iron content varied between 2-40 ppm in Jamalpur soil profile and 8-63 ppm in the Narayanpur soil profile.AvailableMn content varied between 2-40 ppm in Jamalpur, 5-18 ppm in Narayanpur. Soils are generally categorized as having enough manganese if the DTPA extractable Mn content is > 0.2 ppm. Hence all soils of Jamalpur and Narayanpur had sufficient available soil manganese.

3.7 Correlation by colour matrix

Correlation by colour matrix is presented in figure 7. It consists of the correlation of various soil properties variable at various depth (0-100cm) at a different location. The soil profile depths are ranging from 0-5,5-15,15-30,30-60 and 60-100 cm ina different location. The red colour corresponds to (−) negative interaction and blue colour correspond to (+) positive interaction and white correspond to neutral interaction of different soil parameter. In first (A) colour matrix represents the correlation of 0-5 cm depth at a different location. The clay having a positive correlation with porosity as well as water holding capacity (WHC) also showing a positive correlation. In the case of nutrient whereas, the nitrogen having a positive correlation with organic carbon as well as with pH. Most of the nutrients like N, P, Zn and Cu showing a positive correlation with pH. In Second (B) colour matrix represents the correlation of 5-15 cm depth at a different location. Carbon stocks sowing the strong positive correlation with bulk density (B.D.), Clay and Organic carbon (O.C.). The nutrients like N, P and Zn showing a negative correlation with physical properties of soil. In Third (C) colour matrix represents the correlation of 15-30 cm depth at a different location. In this correlation the most of nutrient having a positive correlation with physical properties of soil. Cu, Zn and Mn showing strong positive correlation with physic-chemical properties. Major nutrient does not imply any positive or negative relation. In Fourth (D) colour matrix represents the correlation of 30-60 cm depth at a different location. It does not indicate any positive relationships in the broader way at some point its sowing negative relation but at few points sowing the positive relation like N and Mn having positive relation with chemical properties (pH Soil reaction and Organic carbon). In Fifth (E) colour matrix represents the correlation of 60-100 cm depth at a different location. It clearly shows that few parameters having a positive relation like N and Zn having a positive relationship with physic-chemical properties (Clay, pH, EC and OC). Besides the others nutrients these having a negative correlation with the physical properties of soil.

Conclusion

The Overall Alluvial soils of Mirzapur were mostly soilwas dominantly yellow in colour and had high bulk densities, low to medium water holding capacity and porosity. The pH of the soilwas acidic to neutral. Whereas,most other soils it was neutral to alkaline. Electrical conductivity was low in all soils and organic carbon and carbon stocks were very poor in most soils. The soils did not have any problem associated with calcium and magnesium nutrition. The available N status was poor and available P status in the range of low to medium and potassium status in the medium range in most soils. All the cationic micronutrients were sufficiently supplied in the soil. Hence specific management options must be exerted for agriculture to be profitable in these soils.

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Location	Longitude	Latitude	Soil order	Depth	Colour	Bulk density	Porosity	WHC	Mechanical analysis (%)	Texture classes

Table 1. Physical properties of young alluvial soil.

									Sand	Silt	Clay	
Mirzapur	82.55239	25.01344	Entisols	0-5	5 Y8/2	1.49	43.74	44.0	32	37	31	Clay loam
-	-	-	-	5-15	5 Y8/2	1.74	34.28	43.6	26	45	29	Loam
-	-	-	-	15-30	2.5 Y8/3	1.70	36.01	43.2	28	29	43	Clay
-	-	-	-	30-60	2.5 Y8/3	1.75	33.93	42.4	30	31	39	Clay loam
-	-	-	-	60-100	2.5 Y8/3	1.94	26.70	41.9	26	35	39	Clay loam
Chunar	82.86041	25.11055	Entisols	0-5	5 YR5/2	1.15	56.58	42.8	25	41	33	Clay loam
-	-	-	-	5-15	5 YR5/3	1.37	48.24	42.3	29	43	27	Clay loam
-	-	-	-	15-30	7.5 YR7/2	1.57	40.78	41.3	25	33	41	Clay
-	-	-	-	30-60	5 YR5/3	1.84	30.47	41.0	24	30	45	Clay
-	-	-	-	60-100	7.5 YR7/2	1.74	34.24	40.5	25	31	43	Clay
Chhanbey	82.17392	25.93782	Entisols	0-5	5Y8/3	1.5	43.55	44.4	19	48	33	Silty clay loam
-	-	-	-	5-15	5 Y8/3	1.76	33.51	43.8	43	20	37	Clay loam
-	-	-	-	15-30	5 Y8/3	1.76	33.43	43.1	14	45	41	Silty clay
-	-	-	-	30-60	5 Y8/3	1.78	32.66	42.7	18	43	39	Silty clay
-	-	-	-	60-100	5 Y8/3	1.66	30.38	42.1	12	45	43	Silty clay

Location	Longitude (E°)	Latitude (N°)	Soil order	Depth (cm)	pH	EC (dS m^{-1})	OC (%)	Carbon stocks (Mg ha^{-1})	Exchangeable base (cmol (p+) kg^{-1})		Macronutrients (Kg ha^{-1})			Micronutrients (Mg ha^{-1})			
									Ca	Mg	N	P	K	Zn	Cu	Fe	Mn
Mirzapur	82.55239	25.01344	Entisols	0-5	8.5	0.19	0.65	4.92	3.25	3.45	235	16	207	2	2	29	21
-	-	-	-	5-15	8.3	0.15	0.6	9.32	3.70	5.55	226	12	219	2	1	28	22
-	-	-	-	15-30	8.9	0.2	0.52	12.94	4.10	5.50	216	11	196	2	11	16	23
-	-	-	-	30-60	8.9	0.55	0.24	11.18	4.50	6.25	194	9	173	0	0	12	3
-	-	-	-	60-100	9.1	0.12	0.10	4.98	4.80	7.30	147	8	138	2	1	15	27
Chunar	82.86041	25.11055	Entisols	0-5	8.8	0.22	0.52	2.99	2.25	4.25	267	8	173	9	7	8	21
-	-	-	-	5-15	8.6	0.16	0.51	6.95	3.40	4.30	257	8	184	6	9	11	25
-	-	-	-	15-30	8.7	0.13	0.41	9.73	3.95	7.30	235	8	161	4	6	4	17
-	-	-	-	30-60	8.8	0.52	0.25	14.00	4.40	5.80	220	7	138	3	2	2	9
-	-	-	-	60-100	8.6	0.20	0.15	10.22	4.50	8.50	201	6	127	2	2	2	12
Chhanbey	82.17392	25.93782	Entisols	0-5	6.4	0.23	0.62	4.99	7.00	3.80	191	9	265	2	3	70	24
-	-	-	-	5-15	6.5	0.18	0.43	6.78	7.90	4.50	182	8	219	2	2	46	21
-	-	-	-	15-30	6.9	0.14	0.21	5.16	9.15	5.40	138	7	184	1	0	13	3

-	-	-	-	30-60	6.8	0.14	0.18	12.23	8.20	3.50	132	6	161	1	1	36	16
-	-	-	-	60-100	7.0	0.13	0.13	9.34	9.80	3.42	78	6	138	1	1	15	26

Note: BD = Bulk density, WHC = Water holding capacity

Table 2 Chemical properties of young alluvial soil.

Location	Longitude (E°)	Latitude (N°)	Soil order	Depth (cm)	Colour	Bulk density (Mg m^{-3})	Porosity (%)	WHC (%)	Mechanical analysis (%)			Texture classes (USDA)
									Sand	Silt	Clay	
Jamalpur	83.08624	25.1576	Entisols, Alfisols	0-5	5 Y8/2	1.52	42.51	45.5	39	41	20	Loam
-	-	-	-	5-15	2.5 Y8/2	1.56	41.13	45.1	34	48	18	Loam
-	-	-	-	15-30	2.5 Y8/2	1.64	37.93	44.3	21	57	22	Loam
-	-	-	-	30-60	2.5 Y8/2	1.53	42.35	43.2	27	53	20	Loam
-	-	-	-	60-100	2.5 Y8/2	1.70	35.74	42.7	17	55	28	Loam
Narayanpur	83.03731	25.1879	Entisols, Alfisols	0-5	5 Y8/1	1.61	39.43	41.9	40	39	21	Loam
-	-	-	-	5-15	5 Y8/1	1.59	40.08	41.2	36	42	22	Loam
-	-	-	-	15-30	5 Y8/2	1.66	37.39	41.0	42	41	17	Loam
-	-	-	-	30-60	5 Y8/2	1.67	36.93	40.7	44	37	19	Loam
-	-	-	-	60-100	5 Y8/2	1.74	34.32	40.2	42	42	16	Loam

Table 3: Physical properties of old alluvial soils

Note: BD = Bulk density, WHC = Water holding capacity

Table 4: Chemical properties of old alluvial soil.

Location	Longitude (E°)	Latitude (N°)	Soil order	Depth (cm)	pH	EC (dS m^{-1})	OC (%)	Carbon stocks (Mg ha^{-1})	Exchangeable base (cmol (p+)kg^{-1})		Macronutrients (Kg ha^{-1})			Micronutrients (Mg ha^{-1})			
									Ca	Mg	N	P	K	Zn	Cu	Fe	Mn
Jamalpur	83.08624	25.1576	Entisols, Alfisols	0-5	7.60	0.44	0.33	2.50	5.25	3.10	154	11	276	3	2	12	7
-	-	-	-	5-15	7.80	0.18	0.30	5.24	6.25	3.45	151	10	299	2	2	45	40
-	-	-	-	15-30	8.00	0.20	0.23	6.16	7.50	3.20	100	9	253	1	7	13	15
-	-	-	-	30-60	7.90	0.17	0.22	11.77	6.70	3.45	69	8	219	2	1	2	15
-	-	-	-	60-100	8.20	0.13	0.10	7.63	6.90	3.00	34	7	173	1	1	23	2
Narayanpur	83.03731	25.1879	Entisols, Alfisols	0-5	7.40	0.43	0.48	3.55	2.75	4.50	216	8	184	2	4	63	17
-	-	-	-	5-15	6.20	0.43	0.44	7.66	3.75	5.50	220	8	207	1	3	38	12
-	-	-	-	15-30	8.20	0.04	0.39	9.87	4.30	5.95	166	7	173	1	3	26	18
-	-	-	-	30-60	8.60	0.07	0.26	13.58	5.00	3.90	113	7	138	2	1	8	5
-	-	-	-	60-100	8.40	0.15	0.10	8.04	4.75	6.85	69	7	127	1	1	14	6

Note: EC = Electrical conductivity, OC = Organic carbon

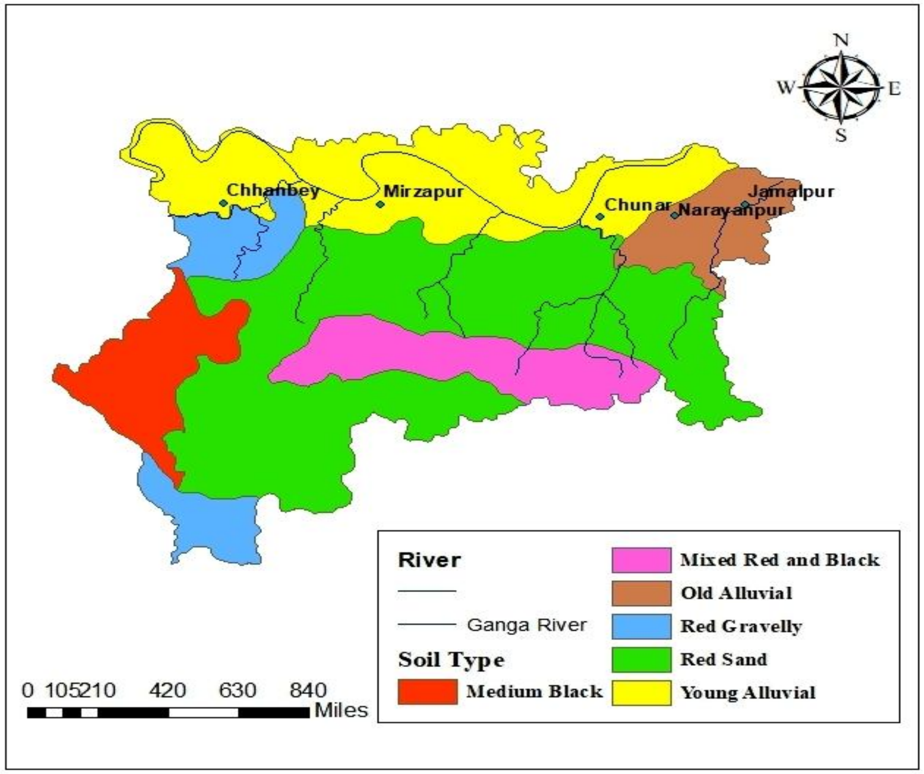
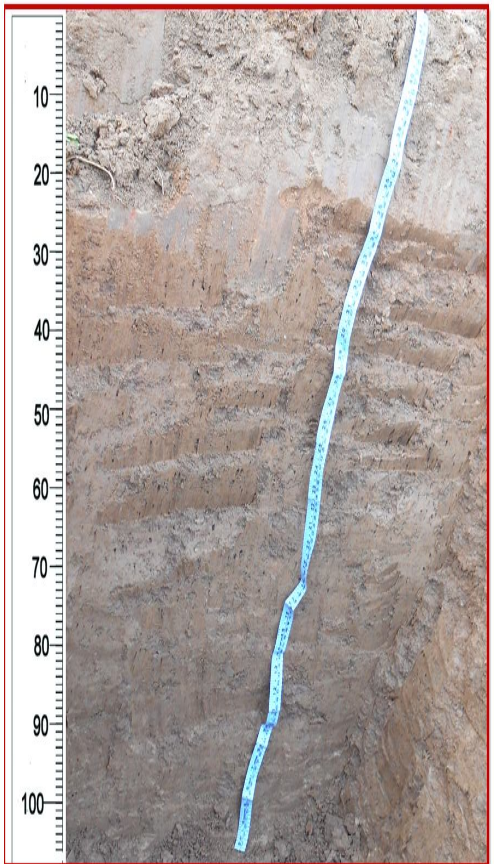


Figure 1-District map of Mirzapur showing soil type and sampling



Soil site description

a) Village: Mirzapur

Latitude: 25.01344 N^0

Longitude: 82.55239 E^0

b) Physiographic: Plain lands

c) Slope:0-1% (Nearly level)

d) Soil- Young alluvial

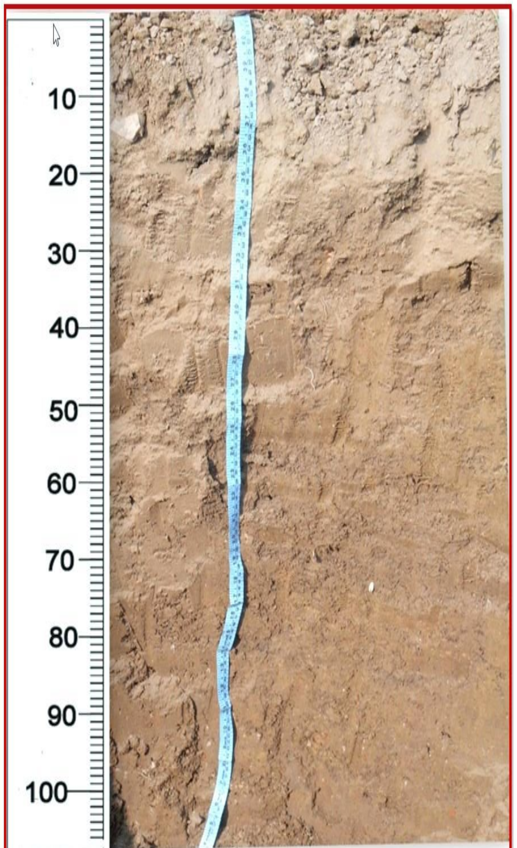
e) Land use: Rice, wheat, green gram

f) Erosion: Nil

g) Drainage: Poorly drained

h) Ground water depth:145ft

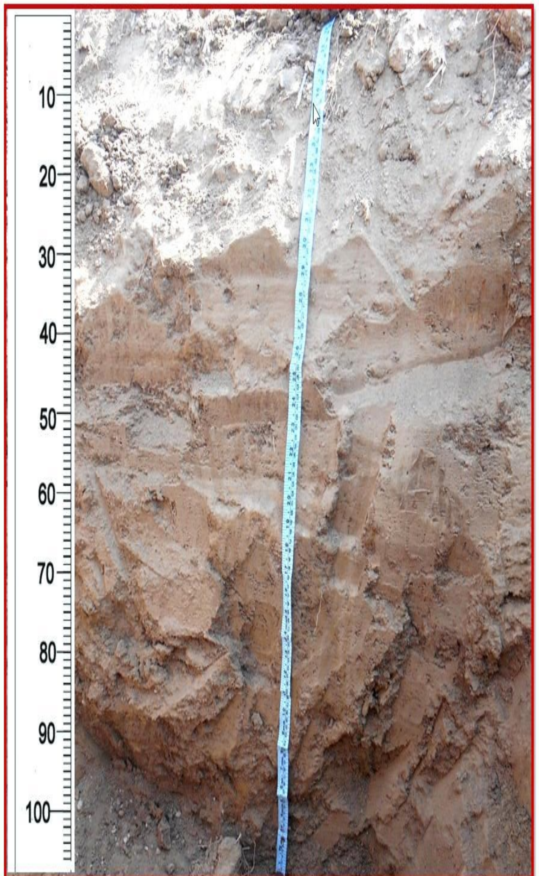
Figure 2-Typical soil profile of Mirzapur



Soil site description

- **a)** Village: Chunar
  - Latitude 25.11055 N^0
  - Longitude 82.86041 E^0
- **b)** Physiographic: Plain lands
- **c)** Slope: Degree: 0-1%
- **d)** Soil-young alluvial
- **e)** Land use: Bajra- wheat, Gram.
- **f)** Erosion: Nil
- **g)** Drainage: Poorly drained
- **h)** Ground water depth: 100 ft.

Figure 3-Typical soil profile of Chunar



Soil site description

- **a)** Village: chhanbey

  Latitude 25.93782 N

  Longitude 82.17392 E
- **b)** Physiographic: Plain lands
- **c)** Slope: Degree: 0-1%
- **d)** Soil- Young alluvial soil
- **e)** Land use: Maize, Potato,
- **f)** Erosion: Nil
- **g)** Drainage: poorly drained
- **h)** Ground water depth: 170 ft.

Figure 4-Typical soil profile of Chhanbey

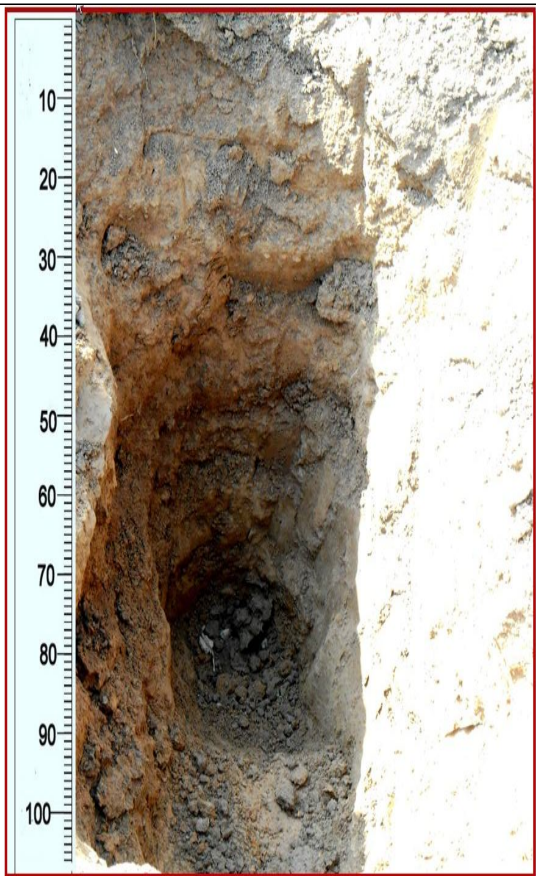
 	**Soil site description** **a)** Village: Jamalpur Latitude 25.1576 N^0 Longitude 83.08624E^0 **b)** Physiographic: Plain lands **c)** Slope: Degree: 0-1% **d)** Soil- Old alluvial **e)** Land use: Maize, potato, rice wheat. **f)** Erosion: Nil **g)** Drainage: Poorly drained **h)** Ground water depth: 70ft.

Figure 5-Typical soil profile of Jamalpur

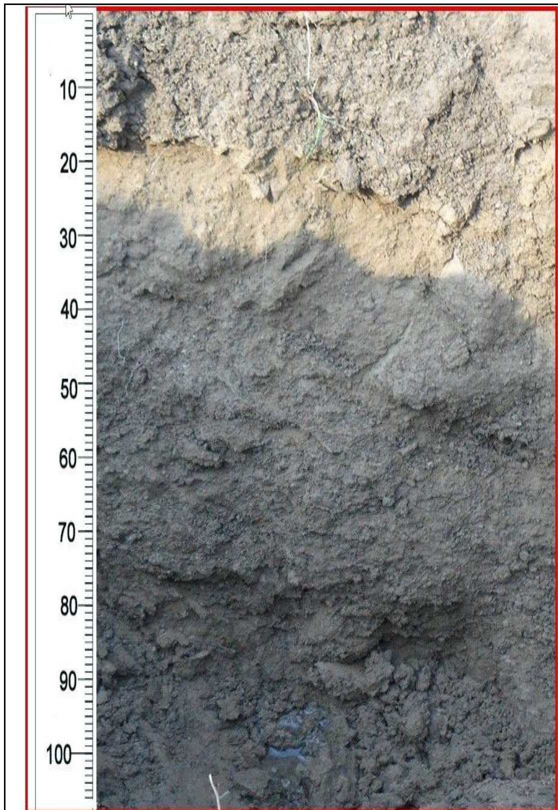


Figure 6-Typical soil profile of Narayanpur

Soil site description

a) Village:Narayanpur

Latitude 25.1879 N^0

Longitude 83.3731E^0

b) Physiographic: Plain lands

c) Slope: Degree: 0-1%

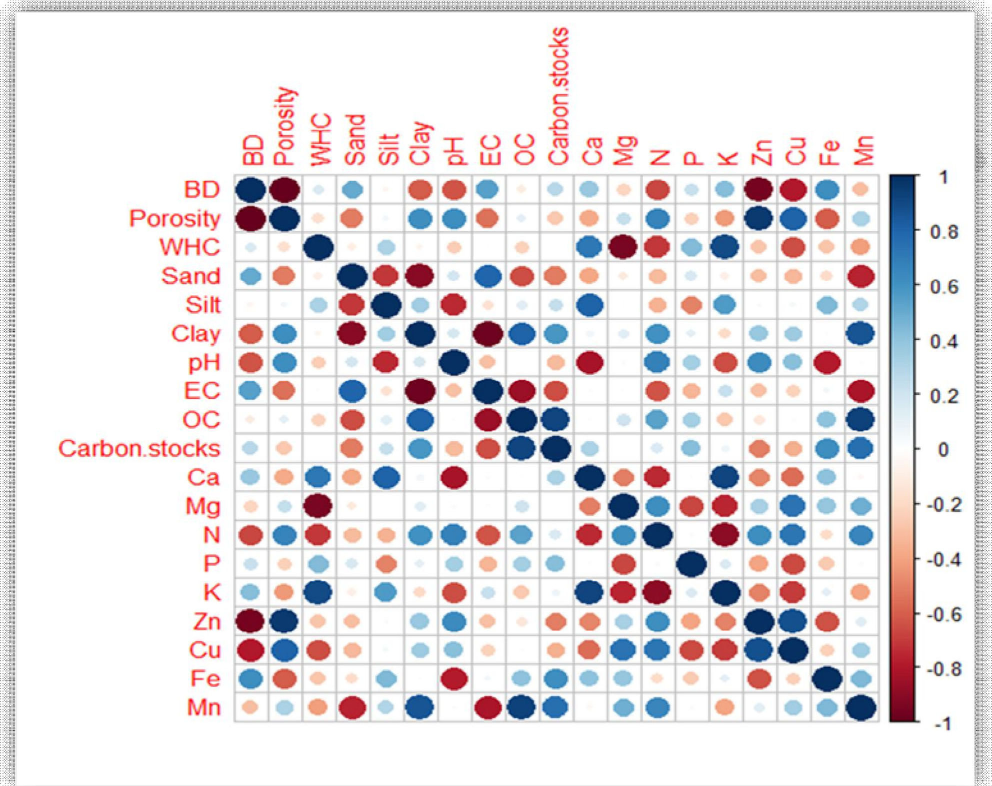
d) Soil- old alluvial

e) Land use: Rice, wheat, gram.

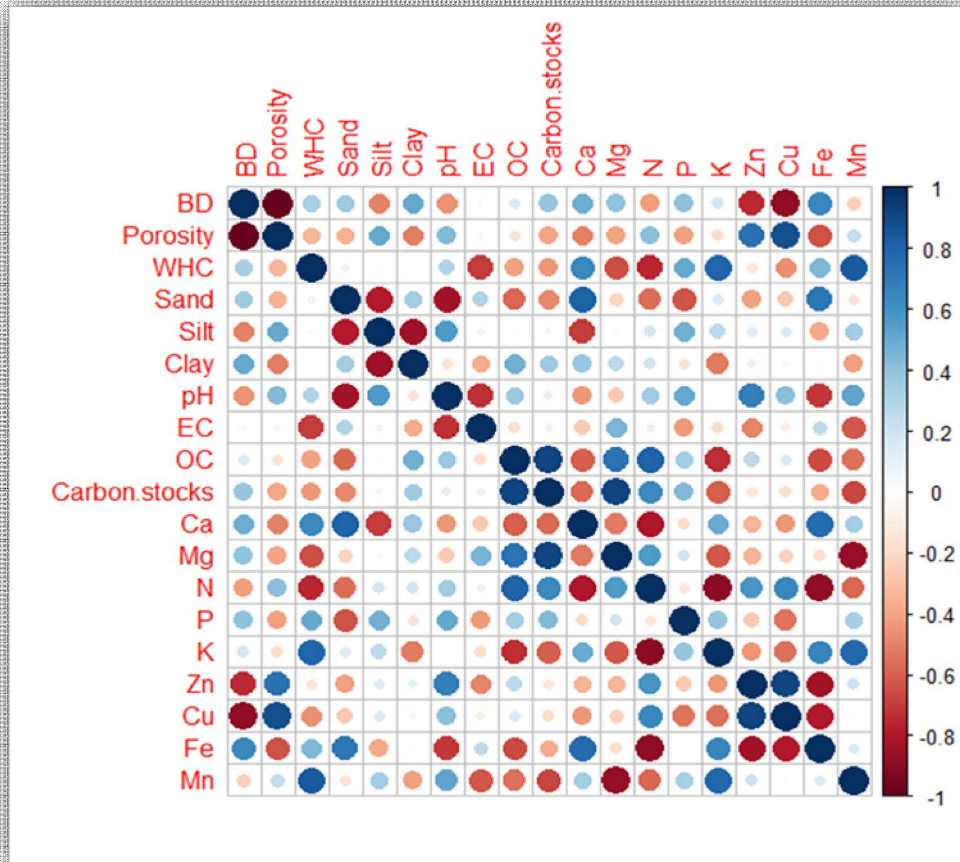
f) Erosion: Nil

g) Drainage: poorly drained

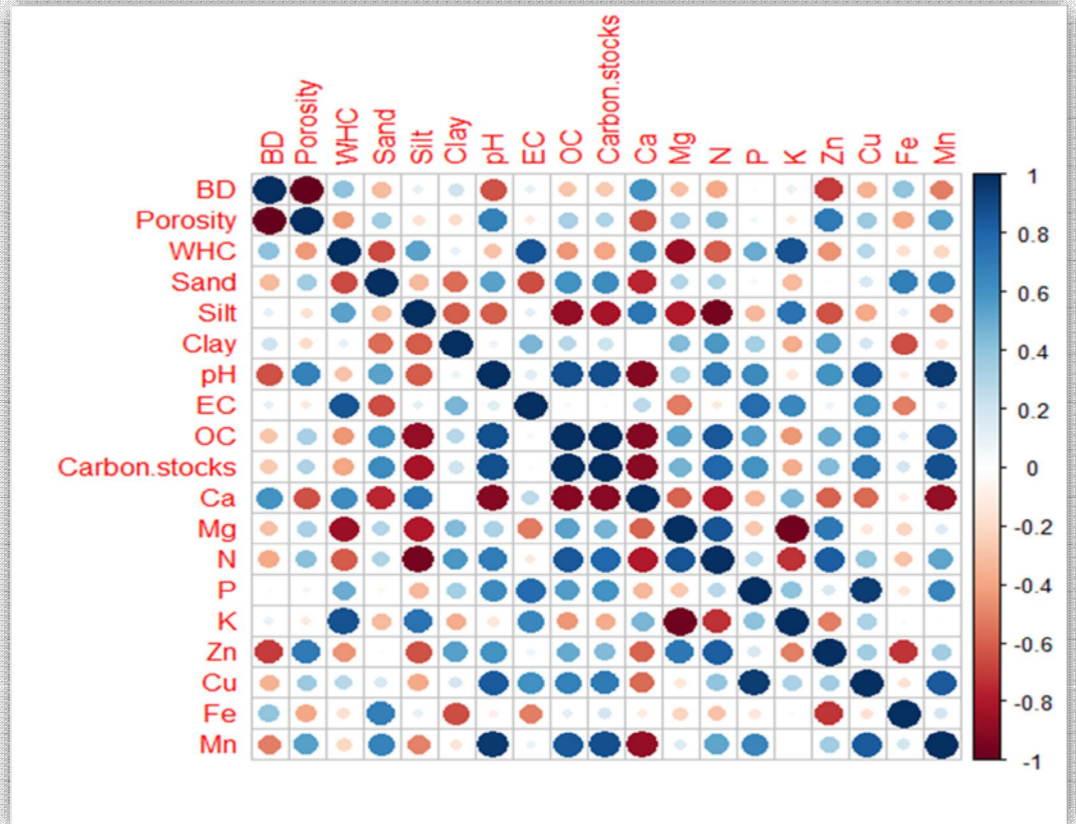
h) Ground water depth: Below 50 ft.



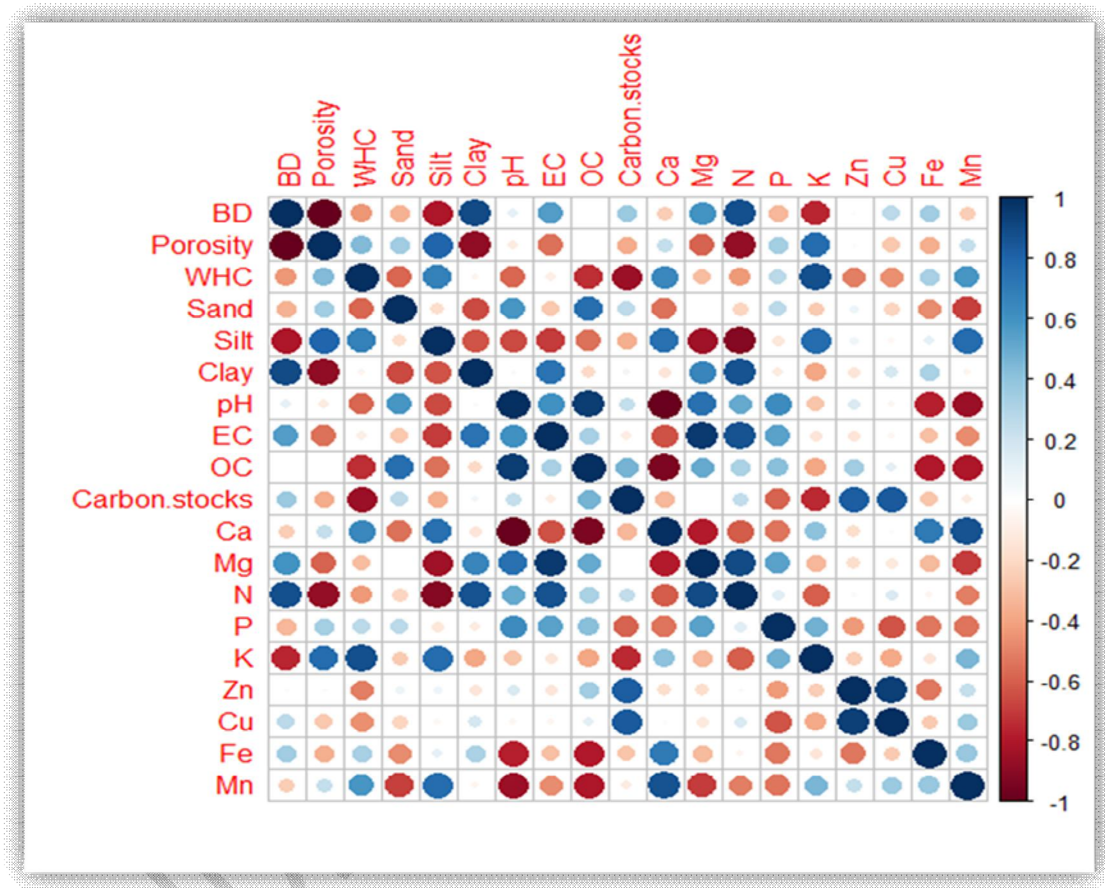
A) Correlation colour matrix of different location at 0-5 cm depth



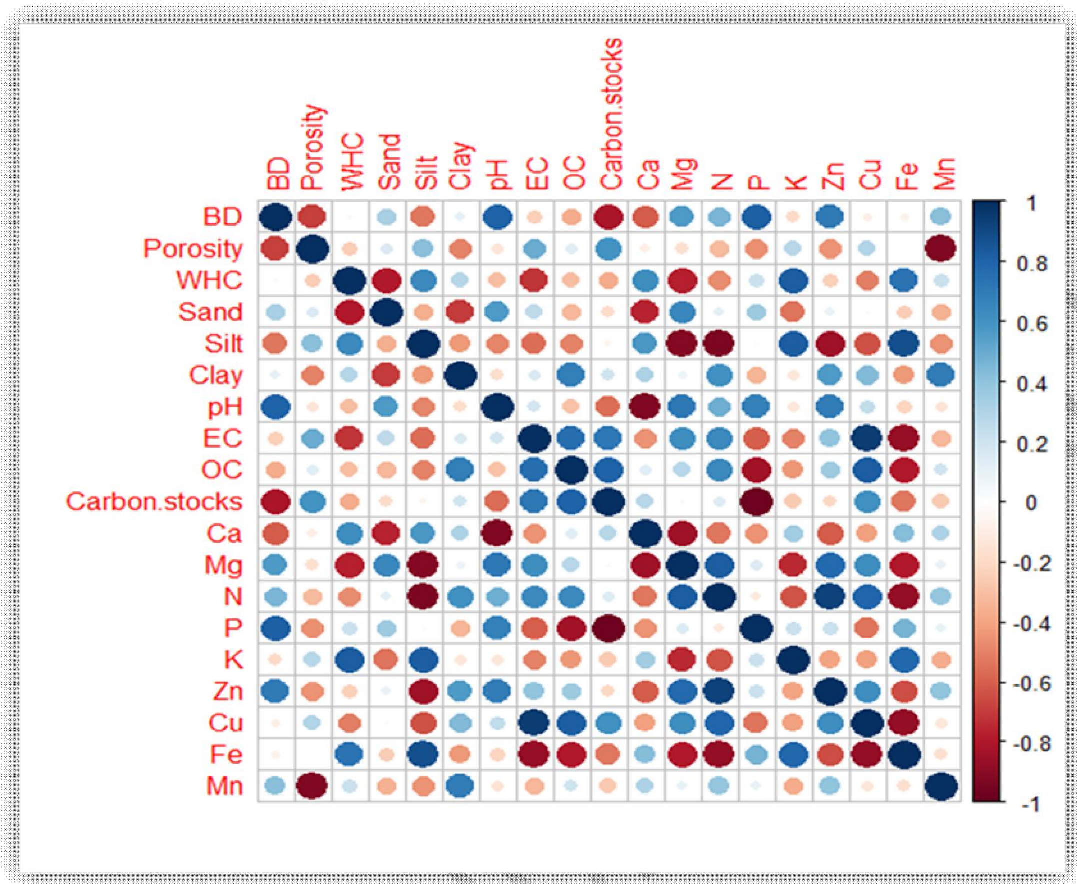
B) Correlation colour matrix of different location at 5-15 cm depth



C) Correlation colour matrix of different location at 15-30 cm depth



D) Correlation colour matrix of different location at 30-60 cm depth



E) Correlation colour matrix of different location at 60-100 cm depth

Figure 7- Correlation colour matrix of different soil parameter in different depth at different location. The red colour corresponds to (−) negative interaction and blue color correspond to (+) positive interaction and white correspond to neutral interaction of different soil parameter.

A) Correlation colour matrix of different location at 0-5 cm depth

B) Correlation colour matrix of different location at 5-15 cm depth

C) Correlation colour matrix of different location at 15-30 cm depth
D) Correlation colour matrix of different location at 30-60 cm depth
E) Correlation colour matrix of different location at 60-100 cm depth

Note: BD = Bulk density, WHC = Water holding capacity, EC = Electrical conductivity, OC = Organic carbon, Ca = Calcium, Mg = Magnesium, N = Nitrogen, P = Phosphorus, K = Potassium, Zn = Zinc, Cu = Cupper, Fe = Iron Mn = Manganese.