Chapter IV

Soil Analysis
SOIL ANALYSIS

The present investigation deals with various mechanical, physical and chemical characteristics of soil of Chohatan, Pachpadra and Sindari areas of Barmer district.

Soil samples were collected from three different sites i.e. Chohatan, Pachpadra and Sindari from different depths. Samples at 0 - 22 cm (superficial) and 22 - 45 cm (deep) were taken and packed in polythene bags and brought to the laboratory for analysis.

Methods for Soil-Analysis

(A) Mechanical Analysis

The mechanical analysis of soil is aimed to determine the % of various size particles - Sand, Silt, and Clay present in the soil.

Diameter of particle

- Sand  2.0 - 0.02 mm
- Silt   0.02 - 0.002 mm
- Clay   below 0.002 mm.

Soil has been dispersed in water with sodium hydroxide. Coarse Sand get separated by sieving, silt and clay by pipette method and fine sand by decantation. For accurate work, the international method called pipette method described by Kilmer and Alexander (1949) has been employed.

Soil sample has been prepared by saturated soil paste; O.M. has been removed by using 30% H₂O₂ solution until no frothing occurs. After complete
removal of O.M., solution is heated continuously for 30 minutes on hot plate to remove excess of H₂O₂.

1. **Separation of Silt and Clay**

   Material was taken in the sedimentation cylinder and stirred for 10 minutes with a motor driven stirrer, then cylinder was enclosed by thermal insulating material and the suspension was allowed to stand overnight. The suspension was stirred for 60 sec. with a hand stirrer, an up and down motion is being used (This stirrer was made by fastening a circular piece of perforated brass sheeting to one end of brass rod.). The time was noted at completion of the stirring. About 1 minute before the sedimentation was completed the tip of 25 ml pipette was lowered slowly into the suspension to the proper depth (10 cm.). The pipette was then filled and emptied into a 60 ml. weighing bottle having an outside cover. One rinse from the pipette was added in bottle and dried in an oven at 95°C and then further dried for 4 hours at 110°C and cooled in desiccators. The temperature of the suspension after each reading was observed.

**Calculation**

\[
\frac{(W_2 - W_1) \times 1000 \times 100}{25 \times 20}
\]

\[
\% \text{ (Silt + Clay) in soil} = \frac{(W_2 - W_1) \times 1000 \times 100}{25 \times 20}
\]

Where, \( W_1 = \text{Weight of bottle} \)

\( W_2 = \text{Weight of bottle + Silt + Clay (in 25 ml suspension)} \)
i. **Clay**

The 2μ fraction i.e. clay was pipetted out from the depth of 20 cm. after a predetermined setting time, in the present study. It was dried, weighed and results calculated as follows -

**Calculation**

\[
\frac{(W_2 - W_1) \times 1000 \times 100}{25 \times 20}
\]

% of Clay = 

Where,

- \( W_1 \) = Weight of dish
- \( W_2 \) = Weight of dish + Clay (in 25 ml suspension)

ii. **Silt**

On subtracting the values of clay % from that of silt and clay [formula (2) from formula (1)], percentage of silt has been determined.

iii. **Fine Sand**

By several time washing to make it free from even a trace of turbidity, the fine sand was being separated and weighed in the soil sample.

In a 500 ml beaker bulk of the sediment obtained earlier was taken and to the height of 10 cm. above the base, distilled water was added. It was stirred well and allowed to stand for prescribed period for observed temperature. Turbid suspension was poured away by decantation and the same process was repeated until the liquid was freed from even a trace of turbidity. The residue was fine sand, it was collected and dried at 70°C and weighed.
Calculation

\[(W_2 - W_1) \times 1000 \times 100\]

\[
\% \text{ of fine sand} = \frac{25}{25}
\]

Where, \( W_1 = \text{Weight of dish} \)
\( W_2 = \text{Weight of dish + Sand} \)

(B) Physical Analysis

1. Absolute specific gravity was determined as described by Piper (1957) by using Ken's bokes.

The specific gravity of the soil is directly related to its bulk density and it may be used as an index of some aspects of soil quality as in case of bulk density.

Method: The soil was dried in an oven at 105°C until a constant weight is attained. A pre-weighed glass bottle of known volume was filled with dried soil and weighed. Another pre-weighed glass bottle of same volume was filled with distilled water and weighed.

Calculation

\[\frac{A_2 - A_1}{B_2 - B_1}\]

\[\text{Specific gravity} = \frac{A_2 - A_1}{B_2 - B_1}\]

Where, \( A_2 = \text{weight of bottle with soil} \); \( A_1 = \text{weight of empty bottle used for soil} \); \( B_2 = \text{weight of bottle with distilled water} \); and \( B_1 = \text{weight} \)
of empty bottle used for water.

2. Maximum water holding capacity or saturation percentage was determined by preparing saturation paste of soil as suggested by Richards (1954).

The water holding capacity of soil depends upon its physical and chemical nature. When the soil is absolutely saturated i.e. water fills all the pores between the particles of soil and there is no air space (as in case of aquatic sediments), the soil is said to be at its maximum water holding capacity or saturation.

Method: The crushed soil sample was dried in an oven at 105°C. A filter paper (Whatman No.1) was placed inside the perforated bottom of the circular soil box, weighed the box, and filled with dried soil sample. Observed the weight of box filled with dried soil, placed the box in Petri dish of 10 cm diameter, containing water, for about 12 hours, so that water enters the box and saturates the soil. Took out the box from water, wiped it, dried its outside surface and recorded its weight.

Calculation

\[
\text{WHC} \% = \frac{(W_2 - W_1) - (W_1 - W_0)}{(W_1 - W_0)} \times 100
\]

Where, WHC = water holding capacity; \( W_0 \) = weight of empty box (g); \( W_1 \) = weight of box with dried soil (g); \( W_2 \) = weight of box with water
saturated soil (g)

3. **Bulk Density:** The bulk density is the total mass of the soil per unit of its total volume, and is expressed as g/cm$^3$. Normally the bulk density ranges from 1.1 to 1.5 g/cm$^3$ for medium to fine textured soil and from 1.2 to 1.65 g/cm$^3$ for coarse textured soil, but it is slight higher in case of alkaline saline soils. The soils with high bulk density are inhibitive to root penetration, and have low permeability and infiltration. The bulk density is inversely related to pore space of soil.

**Method:** The soil sample was dried in an oven at 105°C until a constant weight was attained. Transferred a little dried soil sample to a measuring cylinder and observed its volume and finally recorded the weight of this volume of soil on a balance.

**Calculation**

\[
\text{Bulk density (g/cm}^3\text{)} = \frac{\text{Weight of soil (g)}}{\text{Volume of soil (cm}^3\text{)}}
\]

**Chemical Analysis**

1. **pH (Soil Reaction):** Soil pH was determined by preparing 1:2 soil water suspension by using glass electrode Toshniwal digital pH meter following the method outlined by Jackson (1973).

**Method:** 10 gm of soil was measured in 50 ml beaker. 20 ml of distilled water was added and stirred intermittently with glass rod for half an hour. The
pH of the soil suspension was determined by the pH meter as per directions supplied with the instrument. The suspension was stirred with a glass rod or with a mechanical stirrer again just before taking the pH reading. The electrodes were washed with distilled water after each determination.

2. **Electrical Conductivity**: Electrical conductivity of 1:2 soil water ratio was measured by digital conductivity bridge of 25°C and results were reported mmhos/cm at 25°C (Jackson, 1973).

**Method**: The same soil suspension prepared for the determination of pH was used for E.C. The instrument was checked with the saturated calcium sulphate solution (Specific conductivity - 2.2 mmhos/cm at 25°C) before proceeding with the sample. After recording the soil pH, the soil suspension in the beaker was allowed to settle for 30 minutes. The reading of the soil supernatant was taken by dipping the conductivity cell into it. There should be no air bubble in conductivity tube.

3. **Available Nitrogen**: Available Nitrogen was estimated in the soil samples by using alkaline Potassium Permanganate as reported by Subbiah and Asija (1956).

**Method**: 20 gm of soil was taken in a Kjeldal flask and 20 ml. of water was added followed by 100 ml. each of 0.32% KMnO₄ and 2.5% NaOH solutions. The contents were distilled and liberated ammonia was collected in a flask containing 20 ml of the standard Boric Acid solution
(with mixed indicator). About 100 ml of distillate was collected which was titrated with 0.02 NH₂SO₄ to the original shade (Pinkish).

Available Nitrogen = R \times 0.02 \times \frac{1}{20} \times 0.014 \times 100

Where, R = Volume of 0.20 NH₂SO₄ used in titration.

4. **Available Phosphorus:** Available Phosphorus content was determined by Olsen *et al.*, (1954) method using 0.5 molar Sodium Bicarbonate solution of pH 8.5 as extractant.

**Method:** Colorimetrically, soil extract was prepared by taking 2.5 gm of soil in a 100 ml plastic bottle, a little of Darco G 60 was added following by 50 ml of Olsen's reagent. The flasks were shaken for 30 minutes and the contents were filtered immediately through dry filter paper, 5 ml of soil extract was taken into a flask and 5 ml of Chloro molybedic acid was added. The contents of the flask were diluted to about 22 ml of this 1 ml. of diluted stannous chloride solution was added, shaken and made up to the mark. The intensity of the colour was noted at 660 nm standard. Curve was calibrated with the help of standard phosphorus solution and readings of unknown solution were plotted.

5. **Available Potassium:** Available Potassium was determined by using normal neutral ammonium acetate as an extractant with the help of flame photometer (Jackson, 1973).

**Method:** 5 gm soil was shaken with 25 ml of neutral normal ammonium acetate for 5 minutes and the contents were filtered immediately through
a dry filter paper. First few ml. of the filtrate was rejected. Potassium was estimated in the extract with the help of AMIC digital flame photometer, calibrating it by standard solution.

6. **Carbonates:** Carbonates were estimated by treating the soil with 1N HCl and titrating against 1N NaOH as described by Piper (1957) and reported as percent CaCO₃.

**Method:** 5 to 25 gm of soil was taken in a 150 ml beaker, added 50 ml of .5N standardized hydrochloric acid by means of a pipette, covered with a watch glass and boiled gently for 5 minutes. Cooled, filtered and washed all the acid from the soil with water. The amount of unused acid was determined by adding 2 drops of 1% Phenolphthalein and back titrating with .25N standardized sodium hydroxide.

**Calculations**

\[
\text{CaCO}_3 \text{ equivalent in percent} = \frac{\text{(meq. HCl added - meq NaOH used)} \times 5}{\text{Weight of sample in gm}}
\]

7. **Zinc, Copper and Manganese:** Zinc, copper and manganese were estimated by using Diethylene tetra-amine penta acetic acid (DTPA) as described by Lindsay and Norvell (1978).

**Method:** 10 gm. of soil was taken in 150 ml. bottle and 20 ml. DTPA extracting solution was added into it. The extracting reagent was prepared by taking 1.967 gm of DTPA, 1.470 gm CaCl₂.2H₂O and 13.3
ml of TEA (Triethanol amine) in 100 ml of double distilled water and diluted approximately to 900 ml. The pH of solution was adjusted to 7.3 by adding 1:1 HCl with the help of pH paper. The volume of extracting solution was made to one liter. Standard solution of Zn, Cu and Mn was prepared for concentration of 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 ppm. The contents of flask was shaken on electric shaker for 20 minutes and centrifuged. A blank solution was prepared by adding all the solution except soil by shaking and filtration. The hollow cathode of the micronutrient to be determined was inserted in AAS and started the AAS. The blank solution of 0 ppm was feeded and zero was adjusted in AAS, then the lowest concentration standard was feeded and the reading was noted. After that the reading of standards was taken in increasing order of concentration by running the blank in between two standards to ensure that readings has not changed from zero. The reading of each working standard was taken. Absorbance verses concentration of standards was plotted on graph paper and standard curve was prepared. The sample extract was feeded into AAS and readings were noted. The concentration (ppm) of sample was observed with the help of standard curve.

Observation and Calculation

(i) Weight of soil = 10 gm

(ii) Volume of extractant = 20 ml
Volume of extractant 20

Dilution factor = ------------------------------- = ---- = 2

Weight of soil 10

ppm of micronutrient in soil = ppm. of sample reading × 2

8. **Organic Carbon:** Organic carbon was estimated by using standard K₂Cr₂O₇ solution in the presence of concentrated H₂SO₄ as given by Walkely and Black (1934) method.

**Method:** 1 gm (fine to moderately fine textured) or 2 gm (medium to coarse textured) soil was passed through 0.2 mm sieve (80 mesh per inch) in 500 ml conical flask and added 10 ml of standard 1N K₂Cr₂O₇ solution and well shaked. The flask was kept on an asbestos sheet and then 20 ml. of conc. H₂SO₄ was added by swirling the flask during addition.

The flask was kept at room temperature for 30 min to complete the reaction. A blank was prepared. After 30 minutes 200 ml of distilled water and 10 ml of H₃PO₄ or 0.5 gm sodium fluoride were added and the contents of the flasks were vigorously shaken. 10 drops of diphenyl amine indicator were added. It gave a violet colour to the suspension. Then titrated with N/2 ferrous ammonium sulphate solution till the colour changed from violet to blue or bright green.

The volume of ferrous ammonium sulphate solution was noted. The titration of blank was carried out in similar manner.
Observation and Calculation

Percentage of Organic Carbon in the soil = \( \frac{x-y}{2} \times 0.003 \times 100/S \)

Where,  
\( S = \) Weight of soil sample taken  
\( x = \) Volume (ml) of N/2 ferrous ammonium sulphate solution used for the blank titration.  
\( y = \) Volume (ml) of N/2 ferrous ammonium sulphate solution used for titrating the excess of pot. dichromate.  
\( x-y/2 = \) Volume (ml) of IN K$_2$Cr$_2$O$_7$ used for the oxidation of carbon.

Results and Discussion

Some mechanical and physico-chemical characteristics of the soils of the three sites i.e. Chohatan, Pachpadra and Sindari of Barmer district at different depths are presented in tables (4.1 to 4.3).

In the mechanical analysis of soil sand, silt and clay were quantitatively estimated. The data of mechanical composition (Table 4.1) reveal that the soil of all the three sites largely consists of fine sand followed by silt and then by clay.

The maximum percentage of sand was observed in the Pachpadra soil (88.4%) at a depth of 22 - 45 cm, while minimum (73.2%) in Sindari soil at 22 – 45 cm depth.

Briggs (1904) proposed following groups for classifying soil on the basis of mechanical composition:
(i) **Coarse Textured:** Soils having dominantly coarse texture (sand percentage more than 80%). Two specific classes are - sand and loamy sand.

(ii) **Moderately Coarse Textured:** Soils having dominantly sand (more than 70%) and high percentage of clay. It includes the class sandy loam.

(iii) **Medium Textured:** Soils having dominantly medium texture (sand percentage less than 70% and clay percentage higher than 15%).

Based on above classification, the soils of Chohatan and Sindari areas are moderately coarse textured while the soil of Pachpadra is coarse textured (Table-4.1).

Ritu (2001) also reported that the percentage of sand (70-89%), silt (4 to 15%) and clay (7-18%) in the soil of different sites at Bikaner district.

Harsh (2002) reported that the percentage of sand (73-76%), silt (7-15%) and clay (13-19%) in the soil of different sites at Kodamdesar Pond area of Bikaner district.

Shahid (2002) observed the percentage of sand (57.92%), silt (1.80-17%) and clay (6.20-26%) in the soil of different tehsils of Bikaner district.

Godara (2002) reported the percentage of sand (72-78%), silt (7-12%) and clay (14-18%) in the soil of different sites at Lunkaransar of Bikaner district.

Sudan (2002) reported the percentage of sand (77-92%), silt (3-15%) and clay (5-11%) in the soil of different sites at Churu and Bikaner district.
Khatri (2005) reported the percentage of sand (62-77.4%), silt (15.6-21.9%) and clay (6.1-18.5%) in the soil of different sites at Hanumangarh district.

Gir (2006) has reported the percentage of sand (72-79%), silt (8-11%) and clay (10-19%) in the soil of different sites of waterlogged area of Haunmangarh district.

Khatri (2007) has reported the percentage of sand (14-83%), silt (9-70%) and clay (5-35%) in the soil of Tal Chhapar Wild life Sanctuary area of Churu district.

Singh (2008) has reported the percentage of sand (71-92%), silt (3-15%) and clay (4-14%) in the soil of different sites of Jhunjhunu district.

Bansal (2009) has reported the percentage of sand (69-74%), silt (17.5-21.8%) and clay (4.8-5.5%) in the soil of different sites of Nagaur district.

Arora (2010) has reported the percentage of sand (54.2-65.3%), silt (2.5-8.6%) and clay (16.5-36.1%) in the soil of different sites of Jaisalmer district.

Prajapat (2012) has reported the percentage of sand (71-88%), silt (7.5-16%) and clay (7-16%) in the soil of different sites of Sikar district.

Raghuvanshi (2013) has reported the percentage of sand (71-95.3%), silt (6-14%) and clay (15-20%) in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.

The data presented in table - 4.2 indicates that the water holding capacity was found maximum in Sindari soil (41.48%) at a depth of 22 - 45 cm, while minimum in Pachpadra soil (16.32%) at 0 - 22 cm depth.
The amount of bulk density was observed maximum in Chohatan soil (1.59 gm/cm²) at a depth of 0 - 22 cm and minimum in pachpadra soil (1.40 g/cm²) at a depth of 0 – 22 cm depth (Table-4.2).

Bulk density is inversely related to porosity i.e. bulk density decreases as porosity increases and *vice-versa* (Bodman, 1942).

The maximum percentage of absolute specific gravity was observed in soil (9.34%) at 0 - 22 cm depth, and minimum in pachpadra soil (7.04%) at a depth of 22 - 45 cm (Table-4.2).

The most important chemical property of soil as a medium of plant growth is its pH value. Some soil solution, possess an excess of H⁺ ion over OH⁻ ion and therefore, are acidic. Some show reverse, are alkaline and when there is equal concentration of H⁺ and OH⁻, soil solution are neutral.

The maximum pH value was estimated in Chohatan soil (7.83) at 0 - 22 cm depth, while minimum (7.39) in Pachpadra soil at a depth of 22 – 45 cm (Table - 4.3).

Ritu (2001) has also reported the range of pH between 8.24 – 8.54 from Indira Gandhi Canal irrigated area of Bikaner district.

Harsh (2002) has also reported the range of pH between 8.34 – 8.48 from Kodamdesar Pond area of Bikaner district.

Shahid (2002) has reported the pH range between 8.11-8.67 in the soil collected from different sites of Bikaner district.

Godara (2002) reported the range of pH between 8.28 – 8.48 from
Lunkaransar area of Bikaner district.

Sudan (2002) reported the range of pH between 8.50 – 8.80 from Churu and Bikaner district.

Khatri (2005) reported the range of pH between 7.40-8.74 in the soil collected from different sites of Hanumangarh district.

Gir, Rohitash (2006) has observed the range of pH between 7.85 – 8.62 in the soil collected from waterlogged area of Rawatsar of Hanumangarh district.

Khatri (2007) has studied the range of pH between 8.70 – 9.40 in the soil collected from Tal Chhapar Wild life Sanctuary area of Churu district.

Singh (2008) has studied the range of pH between 7.94 – 8.36 in the soil collected from Jhunjhunu district.

Bansal (2009) has studied the range of pH between 8.55-8.82 in the soil collected from Nagaur district.

Arora (2010) has studied the range of pH between 8.54-9.13 in the soil collected from Jaisalmer district.

Prajapat (2012) has studied the range of pH between 7.9-8.9 in the soil collected from Sikar district.

Raghuvanshi (2013) has recently studied the range of pH between 7.8-8.3 in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.

Maximum electrical conductivity was found in Chohatan soil and Pachpadra soil (0.22 mmhos/cm) at 0 - 22 cm depth and minimum in soil of
Pachpadra (0.10 mmhos/cm) at 22 - 45 cm depth (Table - 4.3).

Ritu (2001) has also been reported electrical conductivity (0.89-1.25 mmhos/cm) in the soil of different Indira Gandhi Canal irrigated area of Bikaner district.

Harsh (2002) has also been reported electrical conductivity (0.25-0.46 mmhos/cm) in the soil of different area of Kodamdesar Pond area of Bikaner district.

Shahid (2002) has observed electrical conductivity (1.02-1.40 mmhos/cm) in the soil collected from different sites of Bikaner district.

Godara (2002) observed electrical conductivity (1.11-1.41 mmhos/cm) in the soil collected from different sites of Lunkaransar area of Bikaner district.

Sudan (2002) observed electrical conductivity (0.49-0.93 mmhos/cm) in the soil collected from different sites of Churu and Bikaner district.

Khatri (2005) observed electrical conductivity (0.40-1.85 mmhos/cm) in the soil collected from different sites of Hanumangarh district.

Gir (2006) has recently found electrical conductivity (0.81 to 1.55 mmhos/cm) in soil collected from waterlogged area of Hanumangarh district.

Khatri (2007) has found electrical conductivity (0.20 to 5.45 mmhos/cm) in soil collected from Tal Chhapar area of Churu district.

Singh (2008) has found electrical conductivity (0.49 to 0.93 mmhos/cm) in soil collected from Jhunjhunu district.

Bansal (2009) has found electrical conductivity (0.10-0.22 mmhos/cm)
in soil collected from Nagaur district.

Arora (2010) has found electrical conductivity (0.10-0.20 mmhos/cm) in soil collected from Jaisalmer district.

Prajapat (2012) has found electrical conductivity (0.62-0.88 mmhos/cm) in soil collected from Sikar district.

Raghuvanshi (2013) has recently found electrical conductivity (0.62-0.88 mmhos/cm) in the soil of different sites at Chatergarh and Kolayat of Bikaner district.

CaCO₃ percentage was found maximum in Sindari soil (4.4%) at 22-45 cm depth while minimum (3.2%) in Pachpadra soil and Chohatan soil at 22-45 cm depth (Table - 4.3).

Randhawa (1996) has also reported similar findings in the soils of Punjab.

Khan, Vangani, Singh and Singh (1999) observed the physico-chemical properties i.e. EC, pH, CaCO₃, particle size distribution in relation to depth of soil of Rawatsar tehsil, Rajasthan.

Acharya (1999) observed the variation in carbonate (1.0-10.95 kg/hectare) in soil of different sites of Bikaner district.

Ritu (2001) reported the variation in carbonate (6.25-15.23) in soil of different sites of IGNP area of Bikaner district.

Harsh (2002) has also reported variation in carbonate (5.75-7.75%) in the soil of Kodamdesar Pond area of Bikaner district.
Shahid (2002) has also reported the variation in carbonate (3.21-4.90%) in the soil of different tehsils of Bikaner district.

Godara (2002) reported the variation in carbonate (9.12-10.41%) in the soil of different sites of Lunkaransar area of Bikaner district.

Sudan (2002) reported the variation in carbonate (8.85-14.05%) in the soil of different sites of Churu and Bikaner district.

Khatri (2005) reported the variation in carbonate (1.40-5.50%) in the soil of different sites of Hanumangarh district.

Gir (2006) has observed variation in carbonate (5.81-8.05%) in the soil of waterlogged area of Rawatsar of Hanumangarh district.

Khatri (2007) has observed variation in carbonate (6.50-10.00%) in the soil of Tal Chhapar Wild life Sanctuary area of Churu district.

Singh (2008) has observed variation in carbonate (8.85-9.95%) in the soil of Jhunjhunu district.

Bansal (2009) has observed variation in carbonate (3.2-4.8%) in the soil of Nagaur district.

Arora (2010) has observed variation in carbonate (3.0-4.3%) in the soil of Jaisalmer district.

Prajapat (2012) has observed variation in carbonate (8.1-9.9%) in the soil of Sikar district.

Raghuvanshi (2013) has recently observed variation in carbonate (6.78-
10.76%) in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.

Arid zone soils are characterised by low organic carbon content for two reasons—scanty vegetation and high temperature for its rapid oxidation.

In the present study, organic carbon content was found maximum (0.13%) in Sindari soil at 22 - 45 cm depth while minimum in Sindari soil (0.09%) at 0 – 22 cm depth (Table - 4.3).

Joshi (1996) reported the organic carbon (0.9 gm/kg) and clay (4%) in arid zone soil of Rajasthan.

Acharya (1999) reported that organic carbon ranged from (0.04-1.05%) at different depth of soil of Bikaner district.

Ritu (2001) has also reported that organic carbon ranged from (0.186-0.336%) at different depth of soil of IGNP area of Bikaner district.

Harsh (2002) has reported that organic carbon ranged from (0.252-0.384%) at different depth of soil of Kodamdesar Pond area of Bikaner district.

Shahid (2002) observed that organic carbon ranged from (0.13-0.28%) at different depth of soil collected from different tehsils of Bikaner district.

Godara (2002) observed that organic carbon ranged from (0.24-0.34%) at different depth of soil collected from different sites of Lunkaransar area of Bikaner district.
Sudan (2002) observed that organic carbon ranged from (0.03-0.16%) at different depth of soil collected from different sites of Churu and Bikaner district.

Khatri (2005) observed that organic carbon ranged from (0.10-0.39%) at different depth of soil collected from different sites of Hanumangarh district.

Gir (2006) has reported that organic carbon ranged from (0.19 to 0.231%) at different depth of soil collected from waterlogged area of Hanumangarh district.

Khatri (2007) has reported that organic carbon ranged from (0.06 to 0.17%) at different depth of soil collected from Tal Chhapar Wild life Sanctuary area of Churu district.

Singh (2008) has reported that organic carbon ranged from (0.15 to 0.04%) at different depth of soil collected from Jhunjhunu district.

Bansal (2009) has reported that organic carbon ranged from (0.22-0.42%) at different depth of soil collected from Nagaur district.

Arora (2010) has reported that organic carbon ranged from (0.22-0.32%) at different depth of soil collected from Jaisalmer district.

Prajapat (2012) has reported that organic carbon ranged from (0.26-0.37%) at different depth of soil collected from Sikar district.

Raghuvanshi (2013) has recently reported that organic carbon ranged from (0.08-0.28%) at different depth in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.
The amount of available nitrogen was observed maximum in Chohatan soil (19 kg/ha) at 0 - 22 cm depth and minimum in Pachpadra soil (10 kg/ha) at 22 - 45 cm depth (Table - 4.3).

Godara (2002) observed the quantity of available nitrogen (16-24 kg/ha) in the soil of different sites of Lunkaransar area of Bikaner district.

Sudan (2002) observed the quantity of available nitrogen (14-25 kg/ha) in the soil of different sites of Churu and Bikaner district.

Khatri (2005) observed the quantity of available nitrogen (14-25 kg/ha.) in the soil of different sites of Hanumangarh district.

Gir (2006) has found the quantity of available nitrogen (16-23 kg/ha.) in the soil of different sites of waterlogged area of Hanumangarh district.

Khatri (2007) has found the quantity of available nitrogen (17-22 kg/ha) in the soil of different sites of Tal Chhapar Wild life Sanctuary area of Churu district.

Singh (2008) has found the quantity of available nitrogen (15-25 kg/ha.) in the soil of different sites of Jhunjhunu district.

Bansal (2009) has found the quantity of available nitrogen (12-20 kg/ha.) in the soil of different sites of Nagaur district.

Arora (2010) has found the quantity of available nitrogen (10-19 kg/ha.) in the soil of different sites of Jaisalmer district.

Prajapat (2012) has found the quantity of available nitrogen (17-22 kg/ha.) in the soil of different sites of Sikar district.
Raghuvanshi (2013) has recently found the quantity of available nitrogen (12-22 kg/ha.) in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.

The value of available phosphorus was observed maximum in soil of Chohatan (25 kg/ha) at 0 - 22 cm depth, while minimum in Sindari soil (18 kg/ha) at the 0 – 22 cm depth (Table - 4.3).

Ritu (2001) has also reported that the phosphorus (28-34 kg/ha) in the soil of different sites of IGNP irrigated area of Bikaner district.

Harsh (2002) reported that the phosphorus (20-29 kg/ha) at the different sites of Kodamdesar Pond area of Bikaner district.

Shahid (2002) observed the quantity of phosphorus (10.50 kg/ha) in the soil of different tehsils of Bikaner district.

Godara (2002) observed the quantity of phosphorus (22-34 kg/ha) in the soil of different sites of Lunkaransar area of Bikaner district.

Sudan (2002) observed the quantity of phosphorus (17-65 kg/ha) in the soil of different sites of Churu and Bikaner district.

Khatri (2005) observed the quantity of phosphorus (21-30 kg/ha) in the soil of different sites of Hanumangarh district.

Gir (2006) has found the quantity of phosphorus (23-32 kg/ha) in the soil of different sites of waterlogged area of Hanumangarh district.

Khatri (2007) has observed quantity of phosphorus (20-60 kg/ha) in the soil of Tal Chhapar Wild life Sanctuary area of Churu district.
Singh (2008) has observed quantity of phosphorus (18-45 kg/ha) in the soil of Jhunjhunu district.

Bansal (2009) has observed quantity of phosphorus (25-50 kg/ha) in the soil of Nagaur district.

Arora (2010) has observed quantity of phosphorus (14-35 kg/ha) in the soil of Jaisalmer district.

Prajapat (2012) has observed quantity of phosphorus (22-39 kg/ha) in the soil of Sikar district.

Raghuvanshi (2013) has recently found the quantity of phosphorus (25-46 kg/ha) in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.

The quantity of potassium was maximum (300 kg/ha) in the soil of Sindari at 0 – 22 cm depth and minimum (190 kg/ha) in the soil of Chohatan at 22 – 45 cm depth (Table - 4.3).

Godara (2002) observed the quantity of potassium (140-190 kg/ha) in the soil of different sites of Lunkaransar area of Bikaner district.

Sudan (2002) observed the quantity of potassium (140-700 kg/ha) in the soil of different sites of Churu and Bikaner district.

Khatri (2005) observed the quantity of potassium (240-520 kg/ha) in the soil of different sites of Hanumangarh district.

Gir (2006) has reported the quantity of potassium (190-310 kg/ha) in the soil of different sites of waterlogged area of Hanumangarh district.
Khatri (2007) has reported quantity of potassium (109-188 kg/ha) in the soil of different sites of Tal Chhapar Wild life Sanctuary area of Churu district.

Singh (2008) has reported quantity of potassium (112-308 kg/ha) in the soil of different sites of Tal Chhapar Wild life Sanctuary area of Churu district.

Bansal (2009) has reported the quantity of potassium (97-210 kg/ha) in the soil of different sites of Nagaur district.

Arora (2010) has reported the quantity of potassium (96-195 kg/ha) in the soil of different sites of Jaisalmer district.

Prajapat (2012) has reported the quantity of potassium (178-380 kg/ha) in the soil of different sites of Sikar district.

Raghuvanshi (2013) has recently reported the quantity of potassium (184-310 kg/ha) in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.

The quantity of micro nutrient zinc was observed high (4.2 ppm) in Chohatan soil at 0 - 22 cm depth and low (3.2 ppm) in Pachpadra and Sindari soil at 22 - 45 cm depth. The quantity of micro nutrient Copper was observed high (3.01 ppm) in Chohatan soil at 0 - 22 cm depth and low (0.36 ppm) in Pachpadra soil at 0 - 22 cm depth. The quantity of micro nutrient manganese was observed high (7.02 ppm) in Chohatan soil at 0 - 22 cm depth and low (5.6 ppm) in Pachpadra soil at 0 - 22 cm depth and Sindari soil at 22 - 45 cm depth (Table- 4.3).

Jha (2000) analysed nitrogen, phosphorus and potash contents of the soil
of Kurukshetra district.


Tripathi and Kumar (2000) were studied the different physico-chemical characteristics of aridisols of western Rajasthan. They reported maximum (26.0%) clay, (0.46%) organic carbon, (9.2) pH, (4.70 ds/m) EC, (2.33%) CaCO₃, (16.5 kg/ha) P₂O₅.

Ritu (2001) has also been reported the Zn, Cu, and Mn of different sites of IGNP area soil of Bikaner district.

Harsh (2002) has also been reported the Zn, Cu, and Mn of different sites of Kodamdesar Pond area soil of Bikaner district.

Godara (2002) reported the Zn (0.38-0.72 ppm), Cu (0.32-0.58 ppm), and Mn (2.97-5.83 ppm) of different sites of Lunkaransar area soil of Bikaner district.

Sudan (2002) reported the Zn (0.18-0.72 ppm), Cu (0.30-0.72 ppm), and Mn (2.97-5.83 ppm) in the soil of different sites of Churu and Bikaner district.

Khatri (2005) reported the Zn (0.09-2.22 ppm), Cu (0.72-0.90 ppm), and Mn (11.00-18.96 ppm) in the soils of different sites of Hanumangarh district.

Gir (2006) has observed the Zn (0.90 to 1.90 ppm), Cu (0.38-1.26 ppm) and Mn (8.32-11.68 ppm) in soils of different sites of waterlogged area of Hanumangarh district.
Khatri (2007) has reported the Zn (0.14 to 0.49 ppm), Cu (0.37-0.72 ppm) and Mn (3.68-5.89 ppm) in soils of Tal Chhapar Wild life Sanctuary area of Churu district.

Singh (2008) has reported the Zn (0.56 to 0.90 ppm), Cu (0.12-0.42 ppm) and Mn (2.54-5.82 ppm) in soils of Jhunjhunu district.

Bansal (2009) has reported the Zn (0.62-1.86 ppm), Cu (0.64-0.89 ppm) and Mn (9.86-12.84 ppm) in soils of Nagaur district.

Arora (2010) has reported the Zn (1.24-5.0 ppm), Cu (0.90-3.2 ppm) and Mn (9.86-12.84 ppm) in soils of Jaisalmer district.

Prajapat (2012) has reported the Zn (0.55-1.5 ppm), Cu (0.25-1.40 ppm) and Mn (3.7-13.05 ppm) in soils of Sikar district.

Raghuvanshi (2013) has recently reported the Zn (0.69-1.16 ppm), Cu (0.48-0.74 ppm) and Mn (2.82-4.18 ppm) in the soil of different sites at Chhatargarh and Kolayat of Bikaner district.
Mechanical Characteristics

The mechanical analysis of soil has been presented in the following table.

**TABLE - 4.1**

Mechanical analysis of soil of different sites

<table>
<thead>
<tr>
<th>Name of site</th>
<th>Depth (cm)</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chohatan</td>
<td>0 - 22</td>
<td>74.6</td>
<td>11.3</td>
<td>14.1</td>
<td>Loamy Sand</td>
</tr>
<tr>
<td></td>
<td>22 - 45</td>
<td>74.2</td>
<td>14.6</td>
<td>11.2</td>
<td>Loamy Sand</td>
</tr>
<tr>
<td>Pachpadra</td>
<td>0 - 22</td>
<td>82.5</td>
<td>7.3</td>
<td>10.2</td>
<td>Sandy</td>
</tr>
<tr>
<td></td>
<td>22 - 45</td>
<td>88.4</td>
<td>6.4</td>
<td>5.2</td>
<td>Sandy</td>
</tr>
<tr>
<td>Sindari</td>
<td>0 - 22</td>
<td>76.3</td>
<td>10.5</td>
<td>13.2</td>
<td>Loamy Sand</td>
</tr>
<tr>
<td></td>
<td>22 - 45</td>
<td>73.2</td>
<td>11.6</td>
<td>15.2</td>
<td>Loamy Sand</td>
</tr>
</tbody>
</table>

Physical Characteristics

The physical analysis of soil has been presented in the following table.

**TABLE - 4.2**

Physical analysis of soil of different sites

<table>
<thead>
<tr>
<th>Name of site</th>
<th>Depth (cm)</th>
<th>Max. water holding capacity (%)</th>
<th>Bulk density g/cm²</th>
<th>Absolute specific gravity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chohatan</td>
<td>0 - 22</td>
<td>39.42</td>
<td>1.59</td>
<td>9.34</td>
</tr>
<tr>
<td></td>
<td>22 - 45</td>
<td>37.65</td>
<td>1.42</td>
<td>8.86</td>
</tr>
<tr>
<td>Pachpadra</td>
<td>0 - 22</td>
<td>16.32</td>
<td>1.44</td>
<td>7.34</td>
</tr>
<tr>
<td></td>
<td>22 - 45</td>
<td>18.24</td>
<td>1.40</td>
<td>7.04</td>
</tr>
<tr>
<td>Sindari</td>
<td>0 - 22</td>
<td>40.73</td>
<td>1.53</td>
<td>8.54</td>
</tr>
<tr>
<td></td>
<td>22 - 45</td>
<td>41.48</td>
<td>1.56</td>
<td>8.86</td>
</tr>
</tbody>
</table>
The chemical analysis of soil has been presented in the following table.

**TABLE - 4.3**

Chemical characteristics of soil of different sites

<table>
<thead>
<tr>
<th>Name of site</th>
<th>Depth (cm)</th>
<th>pH</th>
<th>Electrical conductivity mmhos/cm</th>
<th>Av. Nitrogen (kg/ha)</th>
<th>Av. P₂O₅ (kg/ha)</th>
<th>Av. K₂O %</th>
<th>CaCO₃ %</th>
<th>Zn ppm</th>
<th>Cu ppm</th>
<th>Mn ppm</th>
<th>Org. carb %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chohatan</td>
<td>0-22</td>
<td>7.83</td>
<td>0.22</td>
<td>19</td>
<td>25</td>
<td>4.1</td>
<td>4.2</td>
<td>3.01</td>
<td>7.02</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22-45</td>
<td>7.32</td>
<td>0.20</td>
<td>18</td>
<td>20</td>
<td>3.2</td>
<td>3.8</td>
<td>0.70</td>
<td>6.04</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Pachpadra</td>
<td>0-22</td>
<td>7.60</td>
<td>0.22</td>
<td>12</td>
<td>19</td>
<td>3.5</td>
<td>3.4</td>
<td>0.36</td>
<td>5.6</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22-45</td>
<td>7.39</td>
<td>0.18</td>
<td>10</td>
<td>24</td>
<td>3.2</td>
<td>3.2</td>
<td>0.98</td>
<td>6.3</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Sindari</td>
<td>0-22</td>
<td>7.42</td>
<td>0.19</td>
<td>15</td>
<td>18</td>
<td>3.6</td>
<td>4.0</td>
<td>2.2</td>
<td>6.1</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22-45</td>
<td>7.80</td>
<td>0.21</td>
<td>18</td>
<td>21</td>
<td>4.4</td>
<td>3.2</td>
<td>1.2</td>
<td>5.6</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>