CHAPTER V

HYDRAULIC CONDUCTIVITY WITH DIFFERENT ELECTROLYTE SOLUTIONS FOR DIFFERENT CLAY TYPE SOILS.

Hydraulic conductivity is an important tool to study the movement of water through soils. Specially for the reclamation process of saline and alkali soils. Soil-water complex does not show constant properties due to the following factors which partly or collectively affect the value of hydraulic conductivity.

1. Alternatively wetness and dryness of soil.
2. Saturation and de-saturation of soil.
3. Amount of colloidal clay particles.
4. Type of clay.
5. Cementing material of soil particles.
6. Air pores.
7. Presence of CaCO₃
8. Presence of soluble salts.
10. Organic matter etc.

Every body on the earth's surface is attracted towards the earth's centre by a gravitational force equal to the weight of the body. Soil-matter also obeys the same law.

The presence of solutes in soil water affects its thermodynamic properties and lowers its potential energy. In particular, solutes lower the vapour pressure of soil water.

The osmotic effect is important in the interaction between the plant roots and soil, as well as in processes involving vapour diffusion.

From the standpoint of physical simplicity, however, soil pores are not uniform, smooth tubes but are highly irregular, tortuous and interconnected. Its flow through soil pores is limited by numerous constrictions, or necks, and occasional dead-end spaces.
Saturated flow (saturated conductivity) in saturated soils and unsaturated flow (capillary conductivity) in soils are unsaturated. However, Slatyer (54), concludes that the term hydraulic conductivity, formerly used for water in saturated soils, is now used for both saturated and unsaturated flow. The main difference is that in saturated soils gravity controls the water potential gradient, while in drained soils it is controlled by the potential, and water moves in films surrounding the soil particles rather than by gravity flow through the pores.

The theory of movement of liquid water is based on a generalized form of Darcy's law, which states that the quantity of water passing a unit cross-section of soil is proportional to the difference in hydraulic head. The discharge rate 'Q', being the volume 'V' flowing through the column per unit time 't', is proportional to the cross-section area 'A', to the hydraulic head drop ΔH and inversely proportional to the length of the column 'L':

$$Q = \frac{V}{t} \propto \frac{A\Delta H}{L}$$

The common way to determine the hydraulic head drop across the system is to measure the head at the inflow boundary (Hi) and at the outflow boundary (Ho), relative to some reference level. ΔH is the difference between these two heads, obviously, no flow occurs when ΔH = 0.

The head drop per unit distance in the direction of flow (ΔH/L) is the hydraulic gradient, which is the driving force. The specific discharge rate Q/A (i.e., the volume of water flowing through a cross-sectional area 'A' per time 't') is called the flux density (or, flux), and is symbolized by 'q'.

Thus the flux is proportional to the hydraulic gradient:

$$q = \frac{Q}{A} = \frac{V}{At} \propto \frac{\Delta H}{L}$$

The proportionality factor 'K' is designated as the hydraulic conductivity.

$$Q = K.A. \frac{\Delta H}{L}$$

This equation is known as Darcy's law, after Henri Darcy, the French engineer who first obtained it over a century ago in the course of his classic investigation of seepage rates through sand filters in the city of Dijon.
Fig. No. 1
Downward Flow of Water in a Vertical, Saturated Column.
Flow in a horizontal, Saturated Column.

Fig. No. 2

A. Cross Section
Study upward flow in a saturated vertical column.

Fig. No. 3

Study upward flow in a saturated vertical column.
The linear dependence of flux upon hydraulic gradient, the hydraulic conductivity being the slope (i.e., the flux per unit gradient).
KAOLINITE $Si_4Al_4O_{10}(OH)_8$

- Hydrogen bonding
- $6(OH)$
- $4 Al$
- $4 O*2 (OH)$
- $4 Si$
- $6 O$

C-AXIS

7.2 Å

b-AXIS
example. $x_{08} (Al_{0.3}Si_{7.7}) (Al_{2.6}Fe^{3+}_{0.9}Mg_{0.5}) O_{20}(OH)_4 nH_2O$
ILLITE $K_2Al_2Si_6Al_4O_{20}(OH)_4$
In 1822 Fourier (21) presented a mathematical theory of the transport of heat in conducting materials based on the law that the rate conduction of heat is proportional to the temperature gradient. In 1827, Ohm (42), enunciated his law about the rate of transport of the electricity (i.e. the strength of an electric current) in a conductor, is proportional to the difference of electric potential between its ends. In 1845, Stokes (55), derived more general equations regarding the same aspects. In 1842, Poiseuille (43), experimentally derived the equation of flow of fluid through a tube. The equation has the following from:

\[
\frac{Q}{t} = \left( \frac{\Delta \phi}{l} \right) \left( \frac{\pi}{8\eta} \right) R^4 \rho
\]

were \(Q\) is the volume passing in time \(t\), \(l\) is the length of the tube between the ends of which the potential difference is \(\Delta \phi\), (i.e. \(\Delta \phi /l\) is the potential gradient), \(\eta\) is the viscosity of fluid, and \(R\) is the radius of the tube, \(g = \) acceleration due to gravity and \(\rho = \) density of fluid. However, Darcy (14) formulated the law regarding the infiltration of water vertically through filter beds of sand. From this experiment, Darcy's law can be put in the following from:

\[
\frac{Q}{t} = (K_{wt} \cdot S/l) (H_B + l - H_A)
\]

Where \(K_{wt}\) is the constant characteristic of the porous material. \(H_B\) is the depth of water standing on the upper surface of the sand. \(H_A\) is the depth of the lower face of the sample column below the surface of the water in the layer, \(S\) is the area of cross-section of the flow column. The factor \((H_B + 1 - H_A)\) is the potential difference, i.e. \((B_{wt}^\phi - A_{wt}^\phi)\). Hence the Darcy’s equation can be written as:

\[
\frac{Q}{t} = K_{wt} \cdot S \frac{B_{wt}^\phi - A_{wt}^\phi}{l}
\]

Alternatively, using the relationship between \(\phi_{vol}\) and \(\phi_{wt}\),

\[
\frac{Q}{t} = K_{vol} \cdot S \frac{B_{vol}^\phi - A_{vol}^\phi}{l}
\]

Where, \(K_{vol} = K_{wt} / g\rho\)

\(K_{vol}\) and \(K_{wt}\) differ only in the units in which they are expressed.

The equation indicates that the readiness with which, the material permits the passage of water, and in fact they express the rate of flow through a column of unit
cross-section and having a unit potential gradient. Various names have been suggested for this constant. Following the recommendation of the subcommittee of Permeability and Infiltration of Soil Science Society of America, the name 'Hydraulic conductivity' has been adopted.

Instead of above equation, we can put the following from:

\[ V = - K \nabla \phi \]

considering that the velocity of flow is in a direction opposite to that in which the potential is increasing.

The hydraulic conductivity is a property which depends on nature of the materials as well as on the nature of the fluid. The rate of flow is found to be inversely proportional to the viscosity.

If \( Q/t \) is the volume of liquid flowing per second through a cylindrical tube of radius \( r \) along which imposed potential gradient \( \nabla \phi \) then equation of flow is:

\[ \frac{Q}{t} = (g \rho \pi r^4 \eta) \nabla \phi \]

Improvement on the models has been made by considering the flow of fluid to porous body. Different workers have derived different equations. The following equation is the Kozeny's equation derived in 1927 which is also agreed upon by Fair and Hatch (19) in 1933.

\[ K_T = \frac{(g \rho/2 \eta)}{(1/A^2) [f^3/1(1-f)^2]} \]

This equation can be applied to any kind of porous body. In the equation, the terms involved are \( f \), the area of conducting channel per unit area of cross-section, i.e. \( \eta \pi r^2 \) and \( A \) is the specific surface area developed by the conductor.

Somehow, the structure of the soil is an important factor influencing the flow of the fluid. It is found that Kozeny type formula may fail due to this influence.

The variations due to the structure may be so large that sometimes a hydraulic conductivity which is about 30,000 times as large as expected from the Kozeny formula is realized. On the ground of texture alone Childs and co-workers (11) obtained conductivities which were hundreds of times greater than that could be expected on the textural ground and it may be concluded that the common tendency to texture and conductivity is hazardous.
The difference in experimental values and those calculated from the equation is due to the application to parallel capillary tube and we ignore the random arrays of particles, which are supplied by a natural soil sample.

A reduction of the moisture content is equivalent to a reduction of effective porosity for the purpose of assessing conductivity and results in a reduction of that conductivity. If the material contains a colloidal fraction, than it shrinks as the suction increases, so that all the pore spaces become smaller and this causes a reduction of conduction as the moisture content decreases.

Again, a pore which is full of air, is not merely ineffective as a conductor, but, it becomes as obstacle.

Carmel (8), suggested the following modified equation which suggests that under tortuous condition, a length 'Le' will be occupied in place of length 'L' of the body:

\[
K = (g, \rho/K \eta) \left( \frac{L}{Le} \right)^2 \left( \frac{1}{A^2} \right) \left[ f^3 / (1-f)^2 \right]
\]

Terzaghi (50) and Zunker (64) also have given equations which determine the hydraulic conductivity of porous body.

Nelson and Baver (40), Smith et al. (54), Bendizen and Slater (4) worked out the influence of various factors on hydraulic conductivity.

A hysteresis behaviour has been confirmed by Polovassilis (45).

A downward flow of water in a uniform saturated vertical is shown in Fig. 2.

The upper surface of the column is ponded under a constant head of water \( H_1 \), and the lower surface of which is set in a lower constant level reservoir. Flow is thus taking place from higher to the lower reservoir through a column of length \( L \).

In order to calculate the flux according to Darcy's law, we must know the hydraulic head drop (between the inflow and outflow boundaries) to the column length.

Hydraulic head at inflow boundary = Pressure head + Gravity head

\[
H_i = H_1 + L
\]

Hydraulic head at
outflow boundary

\[ H_0 = 0 + 0 \]

Hydraulic head difference

\[ \Delta H = H_i - H_o = H_1 + L \]

Thus Darcy equation for this case is:

\[ q = K \frac{\Delta H}{L} = K \frac{H_1 + L}{L} \]

\[ q = K \frac{H_1}{L} + K \] \hspace{1cm} (A)

In a horizontal column of soil through which a steady flow of water is occurring from left to right (as shown in Fig. 3) from the upper reservoir to a lower one, in each of which the water level is maintained constant, shows the following behaviour:

\[ q = K \frac{\Delta H}{L} \] \hspace{1cm} (B)

Comparison of two equation (A) and (B) shows that the rate of downward flow of water in a vertical column is greater than in a horizontal column by the magnitude of the hydraulic conductivity.

In the case of upward flow in a vertical column (as shown in Fig. 4) the direction of flow is opposite to the direction of the gravitational gradient, and the hydraulic gradient becomes hydraulic head at inflow \( H_i \).

Hydraulic head at inflow \( H_i \) = Pressure head + Gravity head

i.e. \( H_i = H_1 + 0 \)

Hydraulic head at outflow

\[ H_o = 0 + L \]

Hydraulic head difference

\[ H_i - H_o = H_1 - L \]

The Darcy equation is thus
The hydraulic conductivity is the ratio of the flux to hydraulic gradient, or the slope of the flux vs. gradient curve as shown in Fig. 5.

Smith and Browning (54), suggested that the values for $K$ vary widely, ranging from $<0.0025$ cm/hr. in the least permeable to $>25$ cm/hr. in the most permeable soil. Soils with a hydraulic conductivity of less than 0.25 cm/hr. are poorly drained, while those with conductivities greater than 25 cm/hr. do not hold enough water for fair plant growth.

Permeability or conductivity decreases with decreasing pore space and is sensitive to changes in cation content, which affects the degree of hydration or swelling of clay colloids. Entrapment of air greatly reduces permeability by blocking soil pores. In practice, it is difficult to saturate a soil with water without trapping some air. Entrapped air bubbles block pore passages and decrease the fluid flow.

In many soils, the hydraulic conductivity does not remain constant. According to Reeve et al. (48), Quirk and Schofield (46), and Brooks et al. (7), various chemical, physical, and biological processes play important roles. The hydraulic conductivity may change as water permeates and flows in a soil, change occurring in the composition of the exchangeable ion-complex, as when the water entering the soil has a different concentration of solutes than the original salt solution, can greatly change the hydraulic conductivity. McNeal et al. (34) showed that mixed Na-Mg soils developed lower hydraulic conductivity than Na-Ca soil under similar conditions. Fletcher et al. (22, 23) have studied the Na-Ca-Mg exchange reactions on a montmorillonitic soil.

According to Shiv Kumaraswamy (53), the reduction in hydraulic conductivity was less in alluvial red and laterite soils compared to that in black soils. He also found that hydraulic conductivity increased as the content of divalent salt increased and it decreased with increase in the content of monovalent salts.
Achary and Abrol (2) have studied the effect of river sand on the permeability of sodic soil. According to them, a sharp decrease in hydraulic conductivity occurred with time were sand and soil were mixed in the ratio of 175:25. It is discussed that the clay displacement and subsequent clogging of the pores created by sand additions possibly resulted in reduced water flux, whereas, the surface application of sand prevented the formation of crust just below the sand layer resulting in higher water intake by the soil. Similarly Martin et al. (37) showed that crust formation was the main process responsible for reducing the hydraulic conductivity by several orders of magnitude below that of the remaining soil profile.

Again the hydraulic conductivity 'K' is not an exclusive property of the soil alone. It depends upon the attributes of the soil and of the fluid together. It is possible in theory and sometimes in practice, to separate 'K' into two factors: intrinsic permeability of the soil 'K_1' and fluidity of the fluid 'f':

\[ K = K_1 f \]

Fluidity is inversely proportional to viscosity

\[ f = \frac{\rho g}{r}, \text{ hence } K_1 = \frac{k \cdot r}{\rho \cdot g} \]

where \( r \) = viscosity in poise unit (Cyn/ sec/cm^2).
\( g \) = gravitational acceleration (cm/sec^2)
\( \rho \) = fluid density (gram/cm^3)

An important difference between unsaturated and saturated flow is in the hydraulic conductivity. When soil is saturated, all the pores are filled and conducting, so that conductivity is maximum. When the soil becomes unsaturated, some of the soil cross-sectional area decreases correspondingly. For this reason, the transition from saturation to unsaturation entails a steep drop in hydraulic conductivity, which decreases by several orders of magnitude (some times down to 1/100,000 of its values at saturation) as suction increases from zero to one bar.

According to Bouyoucos (5) the temperature gradients can induce water movement in soil and has been known for at least 50 years. Studies on relative importance and the interaction of thermal and suction gradient in transporting soil moisture were carried out by Hutchinson et al. (28), Philip and deVries (43), Taylor and Cary (57), Cary and Taylor (9) and Cary (10). Saha and Tripathi (51) have studied the effect of temperature on hydraulic conductivity of soils.
In addition to soil water movement, a study of soil aeration is also important because it influences soil productivity.

According to Grim (26), clay particles which absorb water and swell, affect considerably the hydraulic conductivity. The hydration of different cation present in soil complex varies with the type of ions as shown by Jenny (29) and pore space either decreases or increases hydraulic conductivity.

According to Bakker and Emerson (3) and Emerson and Chi (18) and Shainberg et al. (52), the montmorillonite and illite dispersed more easily in presence of Na and Mg compared with Na-Ca.

Felhendler et al. (20) have shown that clay dispersion and clogging of pores within a soil column reduces hydraulic conductivity. In addition to dispersion and clogging of pores within a soil column reduces hydraulic conductivity. In addition to dispersion and clogging of pores, development of their dispersion and clogging of pores, development of their dispersed layer at or near the soil surface (crust formulation) has a strong effect on water movement into a soil.

Diffusion of water into the soil layers is related mainly to the nature of the soil. A study of the hydraulic conductivity changes due to the soil. A study of the hydraulic conductivity changes due to the percolating salt solutions has been carried out by Greacer and Hunon (25), Michaels and Lin (35), Norrish (41) and McNeal and Coleman (33). In the last three decades extensive research has been carried out on the percolation rates of different types of waters such as rain water, canal waters etc. on different type of soils.

According to Doneen and Henderson (16), at any given ESP permeability increased with electrolyte concentration especially in the lower ranges of concentrations and at low levels of exchangeable Na. water with a high concentration of electrolytes, and with Na content > 70% increased the exchangeable Na and rapidly decreased soil permeability. Reeve and Tamaddoni (49) have studies the effect of electrolyte concentration on laboratory permeability and field intake rates of sodic soils and found that measured intake rates in field at high electrolyte concentrations were about three times higher than those of fragmented laboratory samples.

According to Misra (35), the exchange complex is enriched with respect to divalent cations Ca and Mg, whilst the monovalent cations, Na and K, greatly decrease leading to a distinct and sudden fall in PH of the alkali soil on repeated leaching with dilute solutions of Cl\textsubscript{2} MgCl\textsubscript{2} and CaSO\textsubscript{4} The normal soil, good soil and the garden
soil, however, show no such effect. Only the exchangeable magnesium increases as a result of leaching with dilute solution of MgCl₂.

Elswaify and Swindale (17) have studied the effect of saline water on chemical properties of some tropical soils. The salt water on chemical properties of some tropical soils. The salt waters used were similar to sea water and ranged from 0.51 to 0.0061 N. The water inflow varied for different cations and it decreased strongly for Na, slightly for K and Mg and remained constant for Ca.

Bouma and Denning (5) have shown that the hydraulic conductivity (H.C.) is related to soil moisture tension and to the soil texture. Extremely high values for sandy soils were observed by three workers. Waldron and co-workers (22) are of the opinion that the hydraulic conductivity values decreased with depth in texturally homogenous soils due to compression of soil particles in the lower layers. A horizon was related to the low exchangeable sodium percentage (ESP) Values, coarse that pore size distribution rather than total pore volume, governs hydraulic conductivity. Langerwerf and co-workers (31) have reported the hydraulic conductivity to be related to porosity as well as swelling of the soils.

Murashka (38) studied the penetration coefficients of montmorillonite clay soils by aqueous solutions of NaCl, LiCl, AlCl₃ etc. of different concentrations and observed that the penetration coefficients of salt solution decreased in the order:

\[ \text{AlCl}_3 > \text{CaCl}_2 > \text{NaCl} > \text{H}_2\text{O} > \text{LiCl} \]

With respect to concentrations of filtering solutions the penetration coefficients are ordered as:

\[ 2\text{N} > 0.2\text{N} > 0.01\text{N} \text{ for } \text{CaCl}_2 \text{ and } 1\text{N} > 0.01\text{N} > 0.05\text{N} \text{ for } \text{NaCl} \]

He observed that penetration coefficients of clay soils by aqueous solution are determined by soil structural characteristics, change and ionic radius of the solvated cations and their concentrations in solution.

Similary Ramdas (47) has shown that clayey soils rendered impermeable by the swelling action of soil colloids by Na₂CO₃ can be made permeable by treating with 2% solution of any of the following salt solutions.

\[ \text{NH}_4\text{Cl} > \text{NH}_4\text{Br} > \text{BaCl}_2 > \text{SrCl}_2 > \text{CaCl}_2 \]

Colibas, M. et. al (12,13) have shown that decrease in soil permeability occurs when exchangeable sodium reached 10-15% when total soluble salt content is
0.4-0.5%, when soluble Na is 0.08-0.1% and when bicarbonate is about 0.02%. According to these workers, dispersion is the main factor affecting permeability.

Hamid et al. (27) related the dispersion index (DI) with the ESP and the relative hydraulic conductivity (RHC) of a number of soils. As the ESP of the soil decreased and the conductivity decreased, the DI decreased and RHC increased. DI accounted for 80% of the variability in R.H.C. of a salt affected soil. Dispersion indices that can be used as a tool for improving irrigation water quality were suggested.

Moustafa et al. (38) tried to relate the soil bulk density and exchangeable cation to the water permeability and showed that soils saturated with Na were not permeable at any soil bulk density. Effect of exchangeable cations on permeability decreased in the order of Ca > Mg > K, especially at low soil bulk density range. The relative speed of attainment of maximum permeability was also studied by three workers. In Ca-saturated soil maximum permeability is reached in a shorter time than in Mg-saturated soils; in K-saturated soils, it takes a still longer time.

Dixit and Lal (15) while studying the ESP and soil texture and their relation with hydraulic conductivity changes observed that for a clay soil the hydraulic conductivity fall from 2.06 cm/hr in an untreated to 0.07 cm/hr at 29.9 ESP and for a silty clay loam soil: the change was from 3.75 cm/hr in untreated to 0.47 cm/hr in the treated under the same ESP conditions. At the same ESP, the hydraulic conductivity varied from 87% in a loamy sand to 95% in a clayey soil.

Liu, C.L. (32) has studied the leaching of soil columns with salt solutions of 300 meq/litre concentration. The salt solutions were made from NaCl, CaCl₂ and MgCl₂ in different proportions. Adsorbed Ca improved the soil hydraulic conductivity, while absorbed Na reduced it. The soil with adsorbed Mg alone had a lower hydraulic conductivity than the calcium soil, although it was higher than were Na was adsorbed alone. In the presence of Na, however, adsorbed Mg had a detrimental effect on soil hydraulic conductivity of the soils, representing varying texture, clay mineralogy and degree of calcareousness. It was found that the increase in Mg/Ca ration and the SAR and the decrease in the electrolyte concentration of the leaching water increased the dispersion and decreased the hydraulic conductivity of the soils. It is inferred that the effect of Mg is different from that of Ca and the grouping of Ca and Mg together in estimating the SAR may not be desirable for practical purposes.

Abu- Sharar, T.M. et al. (1) and Yousaf, M. et al. (62) have studied the effect of electrolyte concentration and SAR on clay dispersion. They concluded that as
electrolyte concentration decreased and SAR increased, clay dispersion increased and hydraulic conductivity decreased correspondingly.

Water classification for irrigation is based mainly on three ions. Na⁺, Ca²⁺, Mg²⁺.

Sodium Adsorption Ratio (SAR) is the ratio, influencing the soil, for build-up of Exchangeable Sodium Percentage (ESP):

\[ \text{SAR} = \frac{Na^+}{\sqrt{(Ca^{++} + Mg^{++})/2}} \]

\[ \text{ESP} = \frac{100 \left( -0.0126 + 0.01475 \times \text{SAR} \right)}{1 + \left( -0.0126 + 0.01475 \times \text{SAR} \right)} \]

The above equations indicate that Calcium is bunched with Magnesium.

Some workers (33, 35, 41, 24) found that role of Mg is not like Ca but somewhat different and probably of the type of Na.

Water availability is the primary factor for good growth of plants. It is noted that if the soil maintains good hydraulic conductivity, soil structure can be good. For crops like paddy, water logging is required to a certain extent, even then, a high proportion of sodium creates a problem of alkalization and dispersion of soil particles. It is possible to conclude that in addition of soil particles. It is possible to conclude that in addition to texture, the type and sub-type clay minerals together, with their microfine structure and also the origin of that particular clay from rock-source are reflected in hydraulic conductivity behaviour. In fact, a study of hydraulic conductivity in relation with texture and structure of clays are useful for selection of crop to be grown in an area.

With this view, a comparative study has been undertaken. Data for hydraulic conductivity have been presented in Table No: 5.1 to 5.4 and Graphical representation have also been made, Graph No: 5.1 to 5.10.
Table 5.1

HYDRAULIC CONDUCTIVITY (cms/day) WITH DIFFERENT ELECTROLYTE SOLUTIONS FOR DIFFERENT CLAY TYPE SOILS

SOIL: NORMAL

AHMEDABAD: CLAY TYPE K-M-I

NADIAD: CLAY TYPE M

ELECTROLYTE SOLUTIONS: NaCl

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Table 3.2

HYDRAULIC CONDUCTIVITY (cms/day) WITH DIFFERENT ELECTROLYTE SOLUTIONS FOR DIFFERENT CLAY TYPE SOILS

SOIL : NORMAL

AHMEDABAD: CLAY TYPE K-M-I
NADIAD : CLAY TYPE M

ELECTROLYTE SOLUTIONS : CaCl$_2$

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Table 5.3

HYDRAULIC CONDUCTIVITY (cms/day) WITH DIFFERENT ELECTROLYTE SOLUTIONS FOR DIFFERENT CLAY TYPE SOILS

SOIL: NORMAL

AHMEDABAD: CLAY TYPE K-M-I
NADIAD : CLAY TYPE M

ELECTROLYTE SOLUTIONS : MgCl₂

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<td>63.8</td>
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<tr>
<td>5</td>
<td>16.23</td>
<td>72.9</td>
<td>31.30</td>
<td>72.4</td>
</tr>
<tr>
<td>6</td>
<td>14.59</td>
<td>56.8</td>
<td>35.20</td>
<td>55.6</td>
</tr>
<tr>
<td>7</td>
<td>14.59</td>
<td>60.2</td>
<td>38.98</td>
<td>57.9</td>
</tr>
</tbody>
</table>
Table 5.4

HYDRAULIC CONDUCTIVITY (cms/day) WITH DISTILLED WATER FOR DIFFERENT CLAY TYPE SOILS

SOIL : NORMAL

<table>
<thead>
<tr>
<th>AHMEDABAD: CLAY TYPE</th>
<th>K-M-l</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>NADIAD : CLAY TYPE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>hydraulic Conductivity (cms/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
</tbody>
</table>
Hydraulic Cond. $K = \text{Cms/Day}$

Fig 6.4

Hydraulic Cond. $K = \text{Cms/Day}$

Fig 6.5

Hydraulic Cond. $K = \text{Cms/Day}$

Fig 6.6
Fig 5.10

Hydraulic Cond. $K = \text{Cms/Day}$

Days

Distilled Water

- Normal K-M-I Soil
- Normal M Soil

Fig 5.10
Discussion

Data in Table No: 5.1, 5.2 and 5.3 indicate that, the type of clay, plays a significant role and, we find that for 500 PPM NaCl solution the hydraulic conductivity is very low for K-M-I [Ahmedabad 22% clay] soil, as compared to M [Nadiad 44% clay]. For 1000 PPM, NaCl solution the hydraulic conductivity is high in the beginning, but continuously decrease, as the soil complex gets sodium saturated. Again for 2000 PPM NaCl solution the hydraulic conductivity goes on increasing in the beginning due to electrolyte effect, but then decreases due to sodiumization getting higher. In this respect "Montmorillonitic" soil maintains nearly constant flow.

When CaCl$_2$ is taken as percolating solution, data in Tables 5.4, 5.5 and 5.6 indicate that 500 PPM CaCl$_2$ solution, the hydraulic conductivity is higher for K-M-I soil as compared to 500 PPM NaCl. Again for M soil also the hydraulic conductivity values are higher for CaCl$_2$ (500 PPM). For CaCl$_2$, 1000 PPM solution, hydraulic conductivity is much higher both for K-M-I and M soils. This distinctly shows that Calcium soil is a good soil, from point of view of water-movement.

For 2000 PPM CaCl$_2$ hydraulic conductivity values are lower then 1000 PPM CaCl$_2$ solution for K-M-I. This is difficult to explain. Again for M soil the values are changing in M clays.

For MgCl$_2$ solution [Tables No: 5.7, 5.8 and 5.9] the inverse effect of,

1. Increasing of Mg- status
2. Electrolyte effect is seen.

For 500 - PPM MgCl$_2$ solution hydraulic conductivity varies within a short range 32 cms/Day to 14 cms/Day,

Which increases to 70 cms/Day to 39 cms/Day. For 1000 PPM MgCl$_2$ solution, which decreases for 2000 PPM MgCl$_2$ solution or gets in to the range 61 cms/Day to 15 cms/Day. Thus for K-M-I, the two parameters work inversely.

For M soil, the hydraulic conductivity ranges fall in nearly the same ranges [65-78-60] cms/day for 500 PPM MgCl$_2$ [65-72-58] cms/day for 1000 PPM MgCl$_2$ and [72-93-71] cms/day for 2000 PPM MgCl$_2$ solutions.

It is likely that this behaviour difference of K-M-I (Ahmedabad) soil and M (Nadiad) soil, can fully be explained by considering the mineralogical frame work.

Of course, the hydraulic conductivity for distilled water supports the criteria that flow of water through a soil is affected by structure of the soil (Type of clay), quantity of clay and type of electrolyte percolating.
REFERENCES


