IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Permeability Of Sand Due To Submergence Under Saline Water

[1]Amruta Avarade

B.E, Dept. of Civil Engineering,KLS Gogte Institute of Technology Belagavi, India.

[2]Deepti Dandinavar

B.E, Dept. of Civil Engineering,KLS Gogte Institute of Technology Belagavi, India

[3]Dr.Uma.G.Hullur

Professor, Dept. of Civil Engineering, KLS Gogte Institute of Technology Belagavi, India

[4]Abhishek Wathar

B.E, Dept. of Civil Engineering,KLS Gogte Institute of Technology Belagavi, India

[5]Archit Kittur

B.E, Dept. of Civil Engineering,KLS Gogte Institute of Technology Belagavi, India

Abstract: This study examines how the hydraulic conductivity of sand is affected by submersion in saline water. To find out how hydraulic conductivity changes when sand samples are immersed in different amounts of saline solutions, laboratory tests were carried out. The findings show that ionic interactions influencing particle configurations and variations in pore water viscosity cause saline water to modify hydraulic conductivity. The results have ramifications for groundwater research in saline-prone areas and coastal engineering

Index Terms: Hydraulic conductivity, Permeability, Darcy’s Law, Permeameter, Concentration.

I. Introduction

Permeability is a critical parameter in understanding the movement of water through porous media such as soil and sand. It defines the ease with which water can pass through a soil matrix under a hydraulic gradient. The study of hydraulic conductivity becomes particularly significant in coastal and marine environments where saline water plays a dominant role. Submergence of sand under saline water introduces unique physical and chemical interactions, including changes in pore water viscosity, density, and particle interactions, which influence the flow behavior.

Saline water has higher density and viscosity compared to freshwater due to its dissolved salts, which can alter the flow through sand pores. Additionally, the ionic concentration in saline water can influence the arrangement of soil particles and the formation of aggregations, potentially affecting porosity and permeability. Understanding these effects is essential for coastal engineering applications, groundwater management, and environmental assessments in areas impacted by seawater intrusion or tidal variations.

This study aims to determine the hydraulic conductivity of sand when submerged under saline water conditions. By conducting experiments under controlled laboratory settings, the influence of salinity on the hydraulic properties of sand can be analyzed, providing insights into water flow in coastal or saline-prone environments. The findings are relevant for predicting groundwater movement, designing drainage systems, and assessing soil behavior in marine and estuarine regions.

Permeability Definition: Permeability (K) is a property of soil or sediment that indicates how easily water can flow through its pore spaces.

It depends on:

1. The grain size distribution of the soil (sand, in this case).
2. The viscosity and density of the fluid (freshwater vs. saline water).
3. The structure and filling of the soil.
4. Higher Density and Viscosity: Saline water is denser and slightly more viscous than freshwater due to the dissolved salts.

These properties directly affect the movement of water through sand pores, as dense fluids tend to flow more slowly under the same hydraulic gradient. Pore water in the sand is replaced or mixed with saline water. The hydraulic conductivity changes due to the density and viscosity differences of saline water compared to freshwater. Saline water might also lead to physical or chemical changes in the soil.

II. KEY CONCEPTS

1. Hydraulic Conductivity (K):Measure of the sand's ability to allow fluid flow.Influenced by fluid viscosity, density, and sand permeability.
2. Saline Water:Water with dissolved salts, which changes fluid properties.Salinity affects fluid density and viscosity, influencing hydraulic conductivity.
3. Porous Medium (Sand):Sand grain size, porosity, and structure determine how water flows through it.Effective porosity and pore connectivity play a crucial role.
4. Submergence Conditions:Fully saturated sand under saline water.Hydraulic conductivity changes compared to freshwater due to differences in fluid properties.
5. Viscosity of Saline Water:Saline water has higher viscosity than freshwater, reducing the flow rate through the sand.
6. Density of Saline Water:Higher density compared to freshwater, which affects hydraulic gradients and flow rate.
7. Darcy's Law:Used to calculate hydraulic conductivity (K) under controlled conditions.
8. Formula: K=(Q*L)/(A*h*t)
9. Permeameter Test:Experimental setup (constant-head method) to measure hydraulic conductivity of sand under saline conditions.
10. Study of fluid flow through submerged sand under saline conditions for engineering purposes.
11. These terms will guide the determination of hydraulic conductivity under saline water submergence, combining fluid properties, sand characteristics, and experimental methods

III. MATERIALS AND METHODOLOGY

a) Materials and sample preparation.

The material is sand which is cleaned and prepared for various experiments. The sample is sieved through a set of sieves of gradually diminishing opening sizes. The grain size distribution performed using standard sieves. Specific Gravity determined using a pycnometer and Uniformity Coefficient (Cu) and Coefficient of Curvature (Cc) is determined.

Saline Solution is prepared using distilled water and laboratory-grade sodium chloride with different concentrations of 5%, 10%, 15%, 20% and 25%.

b) Methodology

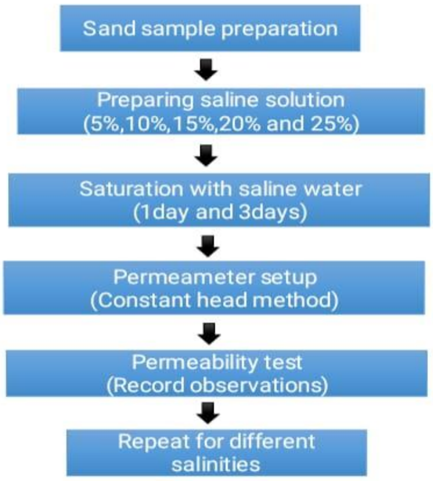

Fig1 Flow chart showing the methodology

IV. Experimentation

1. Oven-dry the sand sample to remove any moisture.
2. Take 2 Kg of sand and saturate the sand with saline solution of (5%,10%,15%, 20%,25%)for 0,1,3 days.
3. Prepare saline water by dissolving a known amount of salt (e.g., NaCl 5%) into distilled water to achieve desired salinity
4. levels.
5. Place the sample in permeameter apparatus.
6. The test is carried by constant head method.
7. Test is repeated for different saline conditions (i.e, 10%, 15%, 20%, 25%).
8. Conduct multiple trials to ensure accuracy and consistency of results.

V. EQUATIONS

Darcy's Law for hydraulic conductivity describes how water flows through a porous medium and provides a quantitative relationship for fluid movement. It is a foundational principle in hydrogeology and soil mechanics.

Darcy's Law (Equation):$(Q*L)/(A*h*t)$

Where:
(Q) = Flow rate (volume of water per time, e.g., m^3/s)
(K)=Permeability (m/s), a measure of the medium's permeability
(A) = Cross-sectional area perpendicular to flow (cm^2)
(h) = Change in hydraulic head (difference in pressure or water levels, in cm)
(L) = Length of the flow path (cm)

Key Assumptions of Darcy's Law:

1. Laminar Flow: The fluid flow is smooth and not turbulent.
2. Homogeneous Medium: The porous material has uniform properties.
3. Saturated Conditions: The material is fully saturated with water.
4. Steady-State Flow: The flow rate does not change with time.

VI. RESULTS

Table 6.1 Results of Constant head permeabilit

Period of submergence(days)	Salinity Concentration(%)	Permeability k (cm/sec)
0 day	5%	0.0161
	10%	0.0142
	15%	0.014
	20% 25%	0.0137 0.0133
1 day	5%	0.022
	10%	0.02
	15%	0.019
	20% 25%	0.017 0.015
3 days	5%	0.023
	10% 15%	0.0211 0.0208
	20%	0.0204
	25%	0.02

Table 6.2: Variation of Permeability versus saline concentration for different period of submergence

Period of submergence	5%	10%	15%	20%	25%
0	0.0161	0.0142	0.014	0.0137	0.0133
1	0.022	0.02	0.019	0.017	0.015
3	0.023	0.0211	0.0208	0.0204	0.02

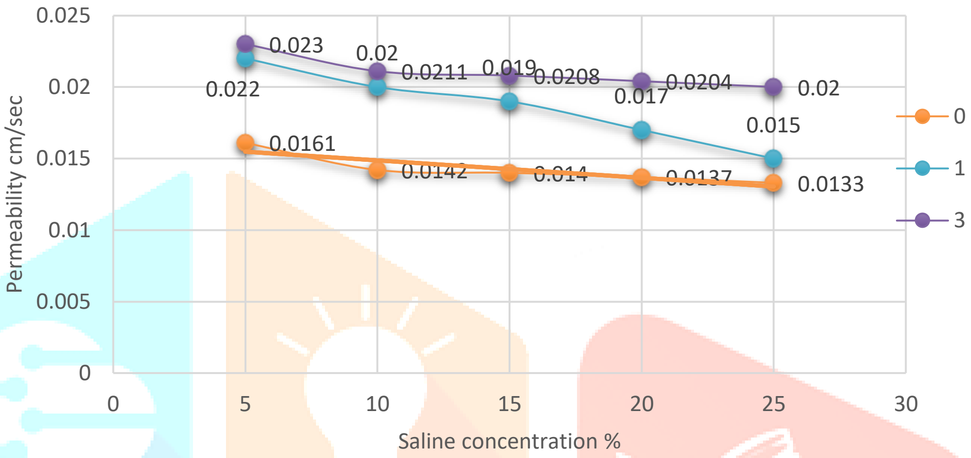

Fig 2: Variation of Permeability versus saline concentration for different period of submergence

Table 6.3:Mathematical modelling: Variation of Permeability versus saline concentration for different period of submergence

Saline concentration 5% to 25%	Day 0	Day 1	Day 3
Linear equation	y = -0.0001x + 0.0161	y = -0.0003x + 0.0237	y = -0.0001x + 0.0231
Regression equation	R^2 = 0.7931	R^2 = 0.9897	R^2 = 0.8325

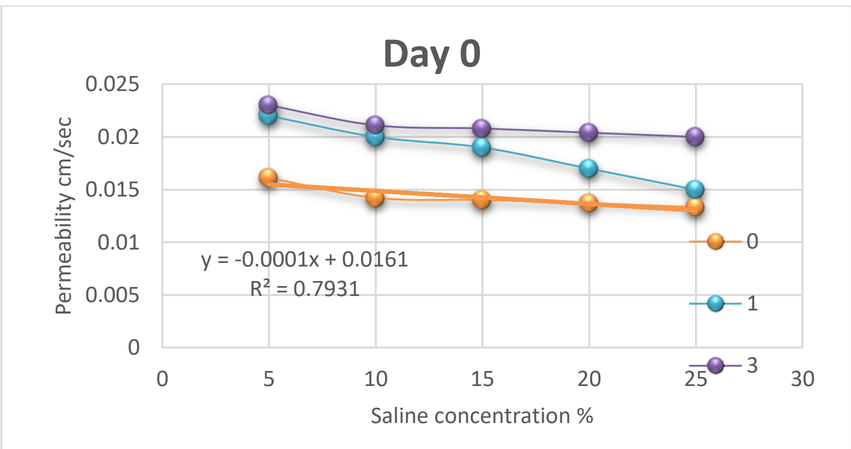

Fig 3: Variation of Permeability versus saline concentration for 0 day of submergence

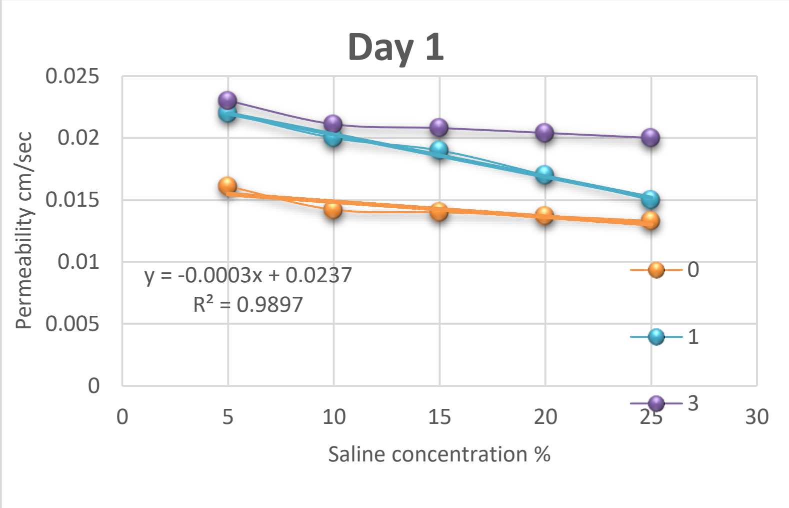

Fig 4: Variation of Permeability versus saline concentration for 1 day of submergence

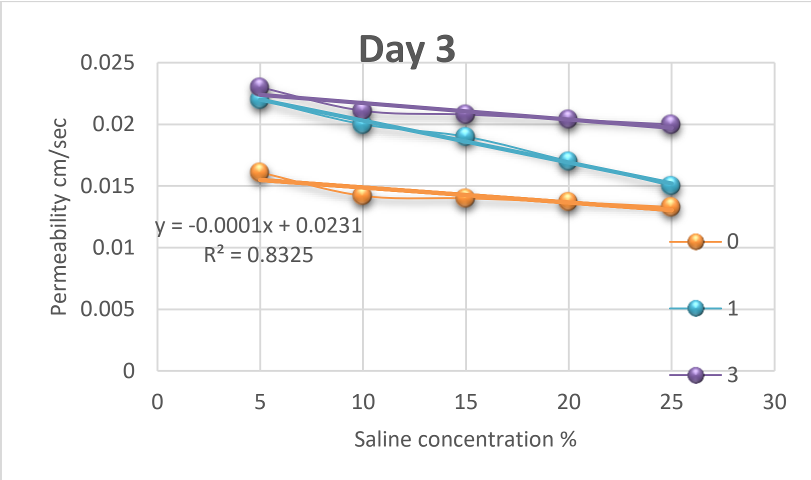

Fig 5: Variation of Permeability versus saline concentration for 3 days of submergence

VII.OBSERVATIONS AND DISCUSSIONS

1. The co-efficient of permeability of natural sand when conducted using constant head method was 0.028 cm/sec.
2. Co-efficient of permeability for 0 day with 5% saturation was 0.0161cm/sec, 10% saturation was 0.0142cm/sec, 15% saturation was 0.014cm/sec, 20% saturation was 0.0137cm/sec, 25% saturation was 0.0133cm/sec.As the salinity increases coefficient of permeability shows the decreasing trend. This reduction is due to the higher ionic concentration in saline water, which affects the sand's pore structure. The dissolved salts in saline water can cause flocculation of fine particles, clogging the sand pores, and reducing water flow through the material.
3. Co-efficient of permeability for 1 day with 5% saturation was 0.022 cm/sec, 10% saturation was 0.02cm/sec, 15% saturation was 0.019cm/sec, 20% saturation was 0.017cm/sec, 25% saturation was 0.015cm/sec.Here also the trend shows decreasing, As the salinity increases coefficient of permeability decreases. This is due to the fact that the higher ionic concentration in saline water, which affects the sand's pore structure. The dissolved salts in saline water can cause flocculation of fine particles, clogging the sand pores, and reducing water flow through the material.
4. Co-efficient of permeability for 3 day with 5% saturation is 0.023cm/sec, 10% saturation was 0.0211cm/sec, 15% saturation was 0.0208cm/sec, 20% saturation was 0.0204cm/sec, 25% saturation was 0.02cm/sec.In this case, and the trend also shows a decrease. As salinity increases, the coefficient of permeability declines. This occurs because the higher ionic concentration in saline water influences the pore structure of the sand. The dissolved salts in the saline water lead to the flocculation of fine particles, which block the sand pores and restrict the flow of water through the material.
5. Co-efficient of permeability for 5% saturation for 0 day submergence was 0.0161cm/sec, 1 day of submergence was 0.022cm/sec, 3 days of submergence was 0.023cm/sec.As the submergence period

increases coefficient of permeability shows the increasing trend. Since the solution is already saturated , further flocculation of particles is not possible and hence the larger void spaces are formed, and this rearranges sand grains, creating larger and more connected flow paths.

6. Co-efficient of permeability for 10% saturation with 0 day submergence was 0.0142cm/sec, 1 day of submergence was 0.02cm/sec, 3 days of submergence was 0.0211cm/sec. As the duration of submergence increases, the coefficient of permeability exhibits an upward trend. With the solution already saturated, further flocculation of particles is not possible. Consequently, larger void spaces are formed, which rearrange the sand grains and create more extensive and interconnected flow pathways.
7. Co-efficient of permeability for 15% saturation with 0 day submergence was 0.014cm/sec, 1 day of submergence was 0.019cm/sec, 3 days of submergence was 0.0208cm/sec. As the submergence period increases, the coefficient of permeability increases as well. Since the solution has already reached saturation, additional flocculation of particles does not occur. This causes the formation of larger void spaces, leading to a rearrangement of sand grains and the development of larger, more interconnected flow paths
8. Co-efficient of permeability for 20% saturation with 0 day submergence was 0.0137cm/sec, 1 day of submergence was 0.017cm/sec, 3 days of submergence was 0.0204cm/sec. With an increase in the submergence period,the coefficient of permeability shows a rising trend.As the solution is already saturated ,no further flocculation of particles takes place.This results in the creation of larger void spaces,which rearranges the sand grains and forms bigger,more connected flow paths.
9. Co-efficient of permeability for 25% saturation with 0 day submergence was 0.0133cm/sec, 1 day of submergence was 0.015cm/sec, 3 days of submergence was 0.02cm/sec. As the submergence period increases the coefficient of permeability tends to rise since the solution is already saturated further flocculation of particles cannot occur.This leads to formation of larger void spaces, causing a rearrangement of sand grains and resulting in larger, more interconnected flow paths.

VIII.CONCLUSIONS:

1. It can be concluded that, the permeability of sand submerged under saline water typically decreases compared to freshwater conditions. This reduction is due to the higher ionic concentration in saline water, which affects the sand's pore structure.
2. The dissolved salts in saline water can cause flocculation of fine particles, clogging the sand pores, and reducing water flow through the material.
3. As the submergence period increases coefficient of permeability shows the increasing trend. Since the solution is already saturated , further flocculation of particles is not possible and hence the larger void spaces are formed, and this rearranges sand grains, creating larger and more connected flow paths.
4. Therefore, saline conditions must be considered in engineering projects involving sandy soils, such as coastal or marine constructions, where accurate permeability assessments are critical for ensuring stability and functionality.

REFERENCES:

1. Fatahi, B., Khabbaz, H., & Basack, S. (2021). Effects of salinity and sand content on liquid limit and hydraulic conductivity. Australian Geomechanics Journal, vol.46(1), 67-76
2. Cui, Y. J., Tang, A. M., Loiseau, C., & Delage, P. (2021). Determining the unsaturated hydraulic conductivity of a compacted sand–bentonite mixture under constant-volume and free-swell conditions. Physics and Chemistry of the Earth Journal, vol.33,(S462–S471).
3. Mahmoud M. Abu Zeid, Ahmed K. Abd El-AalPublished(2019) Effect of salinity of groundwater on the geotechnical properties of some Egyptian clay. Egyptian Journal of PetroleumVolume and Pages: Volume 26, Pages 643–648Year of Publication: 2017
4. Mahmoud M. Abu Zeid, Ahmed K. Abd El-AalPublished(2017) Egyptian Journal of Petroleum Volume and Pages: Volume 26, Pages 643–648
5. R.P. Chapuis,(2016) "Predicting the saturated hydraulic conductivity of natural soils," Geotechnical News, Vol. 26, 2008, pp. 47–50
6. Chan, T.P., and Govindraju, R.S. (2016). "A New Model for Soil Hydraulic Properties based on a Stochastic Conceptualization of Porous Medium", Journal of Water Resources Research, vol. 39, no. 7, pp. 1-5.

7. Basack, S., Goswami, G., Sonowal, S., & Karakouzian, M. (2011). Influence of saltwater submergence on geohydraulic properties of sand: A laboratory investigation. Hydrology,vol.8(issue number 4), 181.