Determination of best suitable site for infiltration well on the basis of infiltration rate of soil

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***Abstract*— Infiltration is the process of penetration of water into the ground surface and the intensity of this process is known as infiltration rate. The infiltration rate is expressed in term of volume of water poured per ground surface per unit of time. Soil erosion, surface runoff & ground water recharge are affected by this process. At a certain moment the maximum infiltration rate can be indicated by the infiltration capacity of soil. Infiltration of water into the soil can be determined by a simple instrument called infiltrometer. The study area to Determination of best suitable site for infiltration well on the basis of infiltration rate of soil to near Ekana Stadium, SadarTahsilLucknw. Experimental work was carried out on clay with medium plasticity clay and sits with low plasticity. Present study double ring infiltrometer was used for measurement. The different soil conditions affect the soil infiltration rate. Infiltration will be maximum at the beginning and it decays exponentially and gets a constant value. Infiltration rate place an important role in generation of runoff volume. The study of infiltration comes in many hydrological problems like runoff estimation soil moisture budgeting and for planning of irrigation.**

***Index Terms:* Infiltration site suitability, permeability properties, of soil suitable site, double ring, infiltrometer infiltration rate.**

1.INTRODUCTION

Infiltration is the process where the water enter surface strata of the soil and move down towards water table. Maximum rate (LT^{-1}).at which a soil in any given Condition is capable for absorbing water is totally soil characteristic. Prevailing rate at which the water entered given soil at any given time is known as Infiltration rate measured by depth (in mm). Hydraulic conductivity is ability of a fluid to flow through a porous medium. It is determined by the size and shape of the pore spaces in the medium & viscosity of fluid. OR It is expressed as the volume of fluid that will move in unit time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow. The steeper the slope (gradient), the less the infiltration or seepage. The more saturated the loose Earth materials are, the less the infiltration. Porosity is the percentage of open space (pores and cracks) in a earth surface. The greater the porosity, the greater the amount of infiltration.sponge clay brick. The clay surfaced soils are compacted even by the impact of rain drops which reduce infiltration. This effect is negligible in sandy soils. Vegetation:- Grasses, trees and other plant types capture falling precipitation on leaves and branches, keeping that water from being absorbed into the Earth & take more time to reach in to the ground. more the vegetation Slower the Infiltration. Roads, parking lots, and buildings create surfaces that are not longer permeable. Thus infiltration is less. At high temperature viscosity decreases and infiltration increases Summer–Infiltration increases Winter–Infiltration decreases furrow irrigation. Entrapped air in pores- Entrapped air can greatly affect the hydraulic conductivity at or near saturation b) Quality of water-Turbidity by colloidal water c) Freezing-Freezing in winter may lock pores. d) Annual & seasonal changes –According to change in land use pattern. Except for Massive deforestation & agriculture.

2-FACTORS WHICH INFLUENCE INFILTRATION

The soil type (texture, structure, hydrodynamic characteristics)

The soil coverage, the topography and morphology of slopes; the flow supply (rain intensity, irrigation flow) The initial condition of soil humidity. Soil compaction due to rain drop impact and other effects. Hydraulic conductivity is ability of a fluid to flow through a porous medium. It is determined by the size and shape of the pore spaces in the medium & viscosity of fluid. OR It is expressed as the volume of fluid that will move in unit time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow.

SLOPE OF THE LAND: - The steeper the slope (gradient), the less the infiltration or seepage.

DEGREE OF SATURATION: - The more saturated the loose Earth materials are, the less the infiltration.

POROSITY: - Porosity is the percentage of open space (pores and cracks) in a earth surface. The greater the porosity, the greater the amount of infiltration.

SURFACE COVER CONDITION:- Vegetation:- Grasses, trees and other plant types capture falling precipitation on leaves and branches, keeping that water from being absorbed into the Earth & take more time to reach in to the ground. MORE the vegetation Slower the Infiltration.
Land Use: - Roads, parking lots, and buildings create surfaces that are not longer permeable. Thus infiltration is less.

TEMPERATURE – At high temperature viscosity decreases and infiltration increases Summer – Infiltration increases Winter – Infiltration decreases FURROW IRRIGATION

OTHER FACTORS – a) Entrapped air in pores- Entrapped air can greatly affect the hydraulic conductivity at or near saturation b) Quality of water- Turbidity by colloidal water c) Freezing- Freezing in winter may lock pores. d) Annual & seasonal changes –According to change in land use pattern. Except for Massive deforestation & agriculture.

3-STUDY AREA

Low land area of Ekana Stadium, TahsilSadar Lucknow in 3km in radius.

Figure:-1 Location of Experimental Sites, SadarTahil, Lucknow

The Latitude of Lucknow Uttar Pradesh, India is 26.84670 N Longitude 80.94620 E. Lucknow is the capital city of Uttar Pradesh.

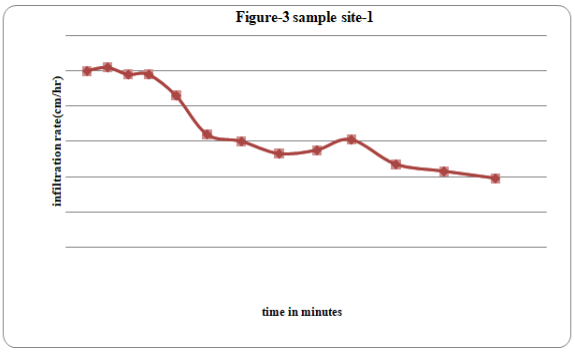
4-OBJECTIVE

To identification of the soil with their properties
To find the infiltration rate by double ring infiltrometer
To suggest the area for suitable site for infiltration

5-METHODOLOGY

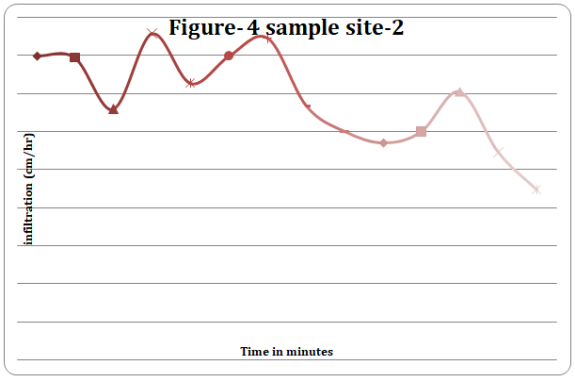
Infiltration of water into the soil can be determined by a simple instrument called Double ring infiltrometer. The cylindrical ring infiltrometer consist of single metal cylinder. These cylinders are partially inserted into the ground and water is filled up to a margin inside the cylinder and after that the speed of penetration of water is measured with respect to the time and depth of penetration of water inside the cylinder. Four types of cylinders are taken for this experiment of diameter 15cm, 30cm, 45cm&60cm and they are experimented as 15-45cm& 30-60cm double ring infiltrometer. To spread the water vertically after infiltration we use double ring infiltrometer. Double ring infiltrometer is better than single ring infiltrometer. In single ring infiltrometer the water will spread horizontally & vertically both, from which water will not move only towards the ground water but using double ring infiltrometer the water will penetrate in one direction that is towards the ground water without much wastage of water.

Figure-2



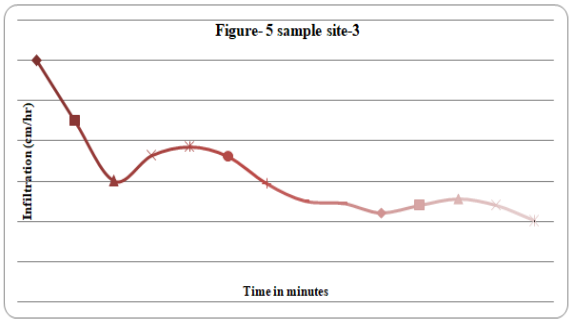
5.1-Sample Site-1

The first sample site is covered by thin grasses. The maximum infiltration rate has found 10.20 cm/hrs and minimum has 3.90 cm/hrs. The average infiltration rate is 6.95 cm/hrs. The infiltration rate has come at constant level only after 125 minutes and reached at stagnant after completion of 140 minutes (Figure-3). The average coefficient of permeability 8.35E-05 cm/sec. and moisture of soil 19.7% the soil of first sample site is 0.00 to 3.0 m. of first strata found clay with medium plasticity second strata from 3.00 meter found clay and silts with low plasticity and third strata from 6.00 meter to 10.0 meter, again consists of a layer of clay with medium plasticity. S.P.T. values obtained in respective clayey layer from 8 to 24 indicating very stiff clay void ratio of soil sample found 0.60 compression index soil found 0.1062 The maximum and even average rate has an unusually high due to less moisture present in sample soil and thin, loose and coarse soil cover. The lateral spread component has observed as a dominant one.



5.2-Sample Site-2

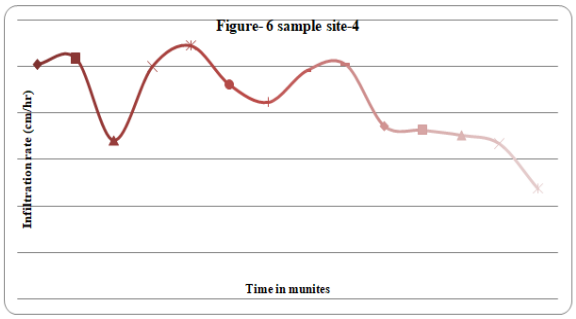
The second sample site is covered by thin grasses. The maximum infiltration rate has found 4.2 cm/hrs and minimum has 2.7 cm/hrs. The average infiltration rate is 3.53 cm/hrs. The infiltration rate has come at constant level only after 146 minutes and reached at stagnant after completion of 226 minutes (Figure-4). The average coefficient of permeability 1.99E-04 cm/sec. and moisture of soil 20.33% the soil of second sample site is 0.00 to 3.0 m. of first strata found clay with medium plasticity second strata from 3.00 meter found clay and silts with low plasticity and third strata from 6.00 meter to 10.0 meter, again consists of a layer of clay with medium plasticity. S.P.T. values obtained in respective clayey layer from 8 to 18 indicating medium to stiff clay void ratio of soil sample found 0.59 compression index soil found 0.105. Infiltration rate has little at initial time period but least difference between minimum and maximum infiltration rate.



5.3-Sample Site-3

The third sample site is covered by thin grasses. The maximum infiltration rate has found 6.0 cm/hrs and minimum has 2.2 cm/hrs. The average infiltration rate is 3.19 cm/hrs. The infiltration rate has come at constant level only after 162 minutes and reached at

stagnant after completion of 262 minutes (Figure-5). The average coefficient of permeability 4.16E-04 cm/sec. and moisture of soil 19.87% the soil of third sample site is 0.00 to 3.0 m. of first strata found clay with medium plasticity second strata from 3.00 meter found clay and silts with low plasticity and third strata from 6.00 meter to 10.0 meter, again consists of a layer of clay with medium plasticity. S.P.T. values obtained in respective clayey layer from 6 to 18 indicating medium to stiff clay void ratio of soil sample found 0.49 compression index soil found 0.109. Infiltration rate has medium and almost constant to end time.



5.4-Sample Site-4

The forth sample site is covered by thin grasses. The maximum infiltration rate has found 5.5 cm/hrs and minimum has 3.0 cm/hrs. The average infiltration rate is 4.34 cm/hrs. The infiltration rate has come at constant level only after 132 minutes and reached at stagnant after completion of 183 minutes (Figure-6). The average coefficient of permeability 2.95E-04 cm/sec. and moisture of soil 20.02% the soil of forth sample site is 0.00 to 3.0 m. of first strata found clay with medium plasticity second strata from 3.00 meter found clay and silts with low plasticity and third strata from 6.00 meter to 10.0 meter, again consists of a layer of clay with medium plasticity. S.P.T. values obtained in respective clayey layer from 7 to 17 indicating medium to stiff clay void ratio of soil sample found 0.59 compression index soil found 0.108 Infiltration rate has observed very little flexible at maximum and average infiltration rate.

6-CONCLUSION

The infiltration depth at the selected time intervals was measured in all the selected sites under different soil conditions based on the double ring infiltrometer field observations. A total four experiments were conducted at Low land area of Ekana Stadium, TahsilSadarLucknow in 3 km in radius. From research work it was found that soil conditions effects infiltration rate. From the graphs of infiltration rates against time it is found that initial infiltration rates were high and decreased with time up to constant infiltration rate. There are many factors which affects the soil infiltration rates. The major factor which affect the infiltration rates are soil parameters. Bulk density and water content were determined for different sites. Therefore the research into the definite relation on influence of soil parameters on infiltration capacity is required to establish As a conclusion, we get the time is found to be constant at volume of water. The soil permeability plays an important role in selecting infiltration capacity. The infiltration curves were plotted against infiltration rate and time for different soil conditions From Figure-3, 4, 5 & 6. It is observed that a high infiltration rate occurs less moisture present in sample soil and thin, loose and coarse soil cover for medium clay and low infiltration rates for stiff compacted soil. As the compacted soil will have low infiltration rate. The infiltration rate also depends on soil characteristics such as soil texture, hydraulic conductivity, soil structure, vegetation cover of the land etc. It was observed that initially infiltration rates were higher and decreased with time up to steady infiltration rate in all the sites where the test has been carried out. The present attempt has an experimental work, measured actual infiltration rate at different sample sites. It is necessary to check infiltration rate for determination of best suitable site for infiltration well. There are other requisites and geographical conditions for the same, but it should be more feasible and suitable with sufficient natural rate of infiltration. Sample site-1 & 4 have observed more than sufficient potential and site 3 has also moderate capacity to infiltrate water for long period of time for maximum ground water recharge. Remaining simple site has not enough potential in case of surrounding infiltration rate.

REFERENCE

[1] Denis Fox ET, The influence of gradient on Infiltration rate for interril condition, In General Geoderma-80(s1-2:181-194: DOI:10.1016/S.0016-7061(97)0075-X Oct 1997

[2] Li chenMicheal ET, Green ampt Infiltration model for sloping surface, July 2006Water Resources Research 42(7) DOI:10.1029/2005WR004468, JULY 2006

[3] Satyawanjagdale, Infiltration studies of different soil under different soil conditions and comprehension of Infiltration model, June 2012International Journal of Engineering & Technology Sciences IJAET/Vol.III/ April-June, 2012/(Issue II):154-157, June 2012

[4] Nitin P. Sonaje, ET Indian journal of applied research Modelling of Infiltration process October 2013

[5] AvinashKadam ET Determination of Infiltration rate for site selection of artificial recharge, July 2015International Journal of Science and Research (IJSR) 5(6):6-391DOI:10.21275/v5i6. NOV164327 July 2015

[6] NileswariYewale ET, Measurement of Infiltration on different land cover, Geomechanics and Engineering Volume 10, Number 6, June 2016, pages 727-736DOI: https://doi.org/10.12989 January 2016

[7] JahagirPoreman ET, An investigation and evaluation Of Infiltration model, Indian Journal of Science and TechnologyDOI: 10.17485/ijst/2016/v9i30/90330 March 2016

[8] Shaid Abdul ET, Effect of soil physical properties on Infiltration rate, June 2016

[9] M.A.Kalan ET, Determination of Infiltration rate and soil indices using double infiltrometer 2016

[10] LuesezambanoRadrigo ET, International journal of science, A spatial model for evaluating the vulnerability of water management in Mexico City Dec. 2016

[11] Mohammad Raja Sadikhani ET, Effect of land use on the performance of sallected soil water Infiltration model 2017

[12] Renato Morbide Carla saltalippi ET, Role on slop of Infiltration, Journal of Hydrology, Volume 557, p. 878-886. Pub Date: February 2018 DOI: 10.1016, February 2018

[13] Kishan Singh Rawat ET, Estimation of infiltration rate from soil properties using regression model for cultivated land, June 2018Geology Ecology and Landscapes 3(2):1-13DOI:10.1080/ 24749508.2018.1481633 24 June 2018

[14] MehandiRahmati ET, Devlopment and analysis of th soil water Infiltration global data base, Earth Syst. Sci. Data, 10, 1237–1263, 2018https://doi.org/10.5194/essd-10-1237-2018© Author(s) July 2018.

[15] Abdul Khaider Aziz Mutshar ET, Determination the Infiltration rate by using a double ring infiltrometer in al jadwal Al Gharbi, June 2019.

[16] Yuije, Xinliang Wu, ET Dynamic study of infiltration rate for soils with varying degrees of degradation by water erosion International Soil and Water Conservation Research Volume-7 page 167-175, Date: 2 June 2019.

[17] Roberta ZambitoMarsala, Impact and prevention of groundwater pollution by pesticides and nitrate in hilly vineyards: evaluation of contamination sources and development of best management practices and mitigation measures, February 2020Environment International 137:105532DOI:10.1016/ j.envint.2020.105532 2019/2020.

[18] SmaranikaMahaPatraET, Evaluated Assessing Variability of Infiltration Characteristics and Reliability of Infiltration Models in a Tropical Sub-humid Region of India, 30 January 2020.

[19] Rama Krishna VeldalanPalli, ET A sturdy of hydrological parameter in Krishna district 2020.

[20] Ajobin Thomas ET, Mapping of Groundwater Recharge Potential Zones and Identification of Suitable Site-Specific Recharge Mechanisms in a Tropical River Basin, Earth Systems and Environment 4(1):131-145DOI:10.1007/ s41748-019-00138-5 March 2020.

[21] DurgaBahadurTiruwa ET, Soil erosion estimation using Geographic Information System (GIS) and Revised Universal Soil Loss Equation (RUSLE) in the Siwalik Hills of Nawalparasi, Nepal, Journal of Water and Climate Change DOI:10.2166/ wcc, The International Conference on Civil and Architecture Engineering 25 July 2020

[22] G.Thabile1, ET, Springer, Assessment of Groundwater Potential in the Kalahandi District of Odisha (India) Using Remote Sensing, Geographic Information System and Analytical Hierarchy Process, in journal in springer Date 09.10.2020.

[23] Mohammed Saleh ET, Derivation of Infiltration Equation Coefficients from Early Available Soil

Parameters in the Soil with Different Level of SARs Scientific/Technical Article • RBRH 26 • 2021 10.1590/2318-0331. 262120200117 2020.

[24] ElineApeneudujustino ET, Estimation of potential groundwater recharge by dry well in Sandy soil., Water SciTechnol (2021) 84 (10-11): 2675–2685 January 2021.

[25] Vikram Kumar, ET Experimental study on infiltration pattern: opportunities for sustainable management in the Northern region of India. 8 March 2021.

[26] Mirko Castellini1*, ET Rapid and accurate measurement methods for determining soil hydraulic properties: A reviewd fraction in soil, land use/land cover, and drainage density 10 August 2021.

[27] VSeongyun Kim1 ET, The site-specific selection of the infiltration model based on the global dataset and random forest algorithm 2021.

[28] Vikram Kumar, ET Infiltration pattern: opportunities for sustainable management in the Northern region of India Water Science Technology 84(1011)2675-2685 Date : 04 May, 2021

[29] Mirko Castellini1*, Simone Di Prima, David Moret-Fernández, Laurent Lassabatere3, 10 August 2021, Rapid and accurate measurement methods for determining soil hydraulic properties: A reviewd fraction in soil, land use/land cover, and drainage density.

[30] VSeongyun Kim1, GülayKarahanManan Sharma1 YakovPachepsky, 2021, The site-specific selection of the infiltration model based on the global dataset and random forest algorithm

Table-1 Infiltration rate measured on the basis of experimental observations

Level in cm	Site-I			Site-II			Site-III			Site-IV		
	Time (Minutes)	Cumulative Time (Minutes)	Infiltration Rate in cm/hrs (F)	Time (Minutes)	Cumulative Time (Minutes)	Infiltration Rate in cm/hrs (F)	Time (Minutes)	Cumulative Time (Minutes)	Infiltration Rate in cm/hrs (F)	Time (Minutes)	Cumulative Time (Minutes)	Infiltration Rate in cm/hrs (F)
0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0
1	6.00	6.00	10.0	15.00	15.00	4.0	10.00	10.00	6.0	11.90	11.90	5.0
2	5.90	11.90	10.2	15.10	30.10	4.0	13.35	23.35	4.5	11.60	23.50	5.2
3	6.10	18.00	9.8	18.20	48.30	3.3	20.00	43.35	3.0	17.60	41.10	3.4
4	6.15	24.15	9.8	14.00	62.30	4.3	16.50	59.85	3.6	12.00	53.10	5.0
5	7.00	31.15	8.6	16.50	78.80	3.6	15.60	75.45	3.8	11.00	64.10	5.5
1	9.40	40.55	6.4	15.00	93.80	4.0	16.60	92.05	3.6	13.00	77.10	4.6
2	10.00	50.55	6.0	14.20	108.00	4.2	20.50	112.55	2.9	14.15	91.25	4.2
3	11.30	61.85	5.3	18.00	126.00	3.3	24.00	136.55	2.5	12.20	103.45	4.9
4	11.00	72.85	5.5	20.00	146.00	3.0	24.60	161.15	2.4	11.90	115.35	5.0
5	9.90	82.75	6.1	21.00	167.00	2.9	27.20	188.35	2.2	16.10	131.45	3.7
1	12.90	95.65	4.7	20.00	187.00	3.0	25.00	213.35	2.4	16.50	147.95	3.6
2	14.00	109.65	4.3	17.00	204.00	3.5	23.40	236.75	2.3	17.00	164.95	3.2
3	15.30	124.95	3.9	22.00	226.00	2.7	25.10	261.85	2.2	18.00	182.95	3.0
4	14.60	139.55		26.80	252.80		30.00	291.85		25.30	208.25	
5	-											
Total	Max F		10.20			4.20			6.00			5.50
	Mini F		3.90			2.70			2.20			3.00
	AVG F		6.95			3.53			3.19			4.34