International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 1, 2025
https://www.theaspd.com/ijes.php

Spatial Variation of Infiltration Rates in Relation to Soil Physical Properties tn Junagadh Taluka (Gujarat-India)

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Received: 05th March 2025
Revised: 18th April 2025
Accepted: 25th April 2025

Abstract: *Infiltration is a critical hydrological process influencing soil moisture, groundwater recharge, and agricultural productivity. Understanding the variability in infiltration rates across regions with semi-compacted soils is essential for sustainable water resource management. However, existing studies often fail to consider the combined effects of environmental factors, such as wind speed and temperature, along with soil structure and land use patterns. These limitations hinder the ability to comprehensively analyse infiltration dynamics, particularly in regions like Junagadh Taluka, Gujarat, India. This study addresses these gaps by evaluating infiltration rates across 24 blocks of Junagadh Taluka using a double-ring infiltrometer. The proposed work investigates the spatial and temporal variability in infiltration rates from 2023 to 2024, considering influencing factors such as soil compaction, vegetation cover, hydraulic conductivity, and environmental conditions. High-resolution measurements were conducted, accounting for soil properties, rainfall history, and surface characteristics, while incorporating map coordinates to analyse spatial distribution patterns. The results reveal a general increase in infiltration rates across most villages, with significant improvements observed in Khadiya (3.64 cm/h) and Toraniya (3.62 cm/h), attributed to better water management practices. Conversely, some villages, like Padariya (-2.41 cm/h) and Makhiyala (-1.21 cm/h), showed declines due to soil compaction and environmental degradation. The study highlights the importance of localized factors in influencing infiltration rates and provides valuable insights into improving water management practices for semi-compacted soils. The infiltration rates, water content and densities are assessed in five villages and the statistical results show the spatial variation and temporal trends as affected by the types of soils and the environment. This research contributes to understanding infiltration dynamics, offering practical recommendations for sustainable soil and water management in similar agro-ecological regions.*

Keywords: *Soil Infiltration Rate, Double Ring Infiltrometer, Soil Physical Properties, Land-Use Patterns, Sustainable Water Management*

INTRODUCTION

Soil water infiltration process is vital in many disciplines which include physical geography, soil science, hydrology, drainage, hydrogeology and irrigation engineering. This then call infiltration, which is the ability of water percolating through soil layers (Chunilal et al., 2024). The amount of water in a soil stratum from irrigation or rainfall during a certain period of time is called the cumulative infiltration; the rate at which water enters the soil during a certain period of time is called the instantaneous infiltration rate; and the total capacity of the soil to take water from irrigation or rainfall during a certain period of time is called the infiltration rate (Dharsenda et al., 2022). The infiltration rate of water through the ground depends on the ground surface moisture status, rainfall magnitude, soil and water temperature, soil biological activities, and characteristics of soil texture, porosity, and compaction and surface cover. In the case of in situ infiltration rate measurement, single or double-ring infiltrometers are mainly used; the double-ring infiltrometer is the preferable option (Kumar, 2023). The inaccuracy that origin from the lateral flow in the soil is well-compensated when using the outer ring. During the use of the double-ring infiltrometer, equal distances between the two rings and measuring only the amount of flow that goes into the inner ring helps in making the right estimation on the infiltration rate. Accumulated in the outer ring does not come into play with the measured vertical infiltration and thus reduces the impact of variation in ring size (Gohil et al., 2024).

Infiltration is the process of assimilation of water into the soil and is an essential hydrologic process because it determines the water that goes into the soil through recharge, that which runs off the surface or that which is use in agriculture. Knowledge of infiltration rates is particularly important in management of water resources, protecting land from erosion, and design of efficient systems of irrigation in areas of complex and varied land use and variability of soil types (Mozzi et al., 2021). Junagadh Taluka within Gujarat State of India is agro-important taluka having a diversity in terms of landform, soil, and climate. These differences call for a studied effort to determine the factors that govern the infiltration rates spatially in relation to the characteristics of soil physical. Soil texture, structure, porosity, bulk density and practices of land use are major factors, which determine rate of infiltration. Changes in all these parameters lead to different water holding capacities which in turn impact on issue of soil health, crop productivity and water resource management (Kakwani et al., 2024). Infiltration rates therefore must be measured as closely as possible to support the right agricultural practices for the farming sector and to avoid the negative impacts of water logging and soil erosion.

Effective water resource management is one of the most pressing challenges in regions like Junagadh Taluka, Gujarat, where agricultural productivity and environmental sustainability heavily depend on understanding soil-water interactions. Infiltration as one of the key hydrological processes influences recharge to groundwater regimes, irrigation water use, and staving off of soil erosion. But the spatial distribution of infiltration rates, which are affected by the texture, porosity, bulk density, and land use status of the soil, still receives limited analysis in this area. The Junagadh Taluka is one of those unique places that can provide insight into the relation between the infiltration rates and soil physical properties due to variation in its geographical environment. The growing importance of water in agriculture, or problems such as erosion, water logging or a falling water table, have underlined the need for good quality data to help with better water and soil management. Although a number of improved measurement techniques are available in the field of infiltration the double ring infiltrometer method which is regarded as accurate and commonly used for infiltration study has not been adopted optimally in this context. This is because the system has the capability to deliver accurate vertical infiltration data; features that can help to address the existing knowledge deficit in the region's soil hydrology.

The research process starts with the Indian Standard Code IS 2720 (Part 28): 1986. The double ring method also reduces lateral flow so that measurements made will strictly be on vertical infiltration. It is expected that from the study of infiltration rates and their relationship with SPP, this study will be useful in improving understanding of the Junagadh Taluka's hydrological behaviour. The findings of this research will be helpful to pinpoint regions and areas with different intensity of infiltration and to design water management and future agriculture for the regions with consideration of soil and climatic conditions.

RESEARCH MOTIVATION

This research aims at obtaining practical information on the infiltration dynamics of the region and its applicability to water utilisation, irrigation and agricultural productivity in arid lands. So, while associating infiltration rates with the characteristics of the physical properties of soils, the study focuses on the formulation of the site-specific conservation measures for improvement of the soil and its use in agriculture, as well as the purpose of other global objectives in the sphere of water safety and ecological stability.

RESEARCH CONTRIBUTION

The Key Contributions of the Research are:

1. This paper presents an evaluation of spatial variability of the infiltration rates of the soil of Junagadh Taluka by applying Double Ring Infiltrometer method.

2. Characterises relations between infiltration rates and such essential parameters of the soil as the texture, porosity and bulk density.

3. Examine the diverse patterns of land utilization with the aim of determining a clear relationship between the former and soil infiltration capacity, which the book will find useful as relates to sustainable agriculture and land use.

4. Adopts the Indian Standard Code IS 2720 (Part 28): In 1986 the presented investigation was carried out, providing accurate, repeatable and scientifically sound infiltration measurements.

5. It supports decision making intended for management of water resources supplement, soil protection and water rationing for irrigation in arid areas.

This paper is organized as follows: Section 1 explains the topic's research objectives and its importance. Section 2 provides an account of some of the studies identifying infiltration and soil characteristics. Section 3 explains the method used in this research; the double ring infiltrometer technique. Section 4 provides the findings': Last, Section 5 provides an analysis of major findings, a discussion of the findings' impact on the current and future practices for soil and water management, and recommendations.

RELATED WORKS

Zhu et al.(2024) emphasize that Hydrological and erosion processes depend on other infiltration characteristics of soil including the infiltration rate and the saturated hydraulic conductivity, otherwise known as SIPs. Thus, flow and processes of these specific intensity and patterns of watersheds are critical under different land use and cover to control soil erosion in small agricultural watersheds and for sustainable development. Nevertheless, little comparison study has been fulfilled to compare the characteristics of SIPs, and to explore what variables constitute the most important factors for explaining land use/cover changes in the black soil region of Northeast china. To this end, eight typical land use/cover types were chosen to examine the variability in SIPs across these categories and to assess the primary factors affecting them. Using a tension disc infiltrometer with pressure heads of -3, -1.5, and 0 cm, the SIPs—including initial infiltration rate (IIR), steady infiltration rate (SIR), and saturated hydraulic conductivity (Ks)—were measured under eight land use/cover types: Forest and Woodlands, Savanahs, Pastures and Ranges, Linear Windbreaks, Cross Windbreaks, Accessory Farm Roads, and Cornfields of Zea mays L. and Glycine max (Linn.) Merr. Porosity efficiency and porosity productivity were also calculated from those pressure heads. Analysis of variance of the degree of freedom showed that there were highly significant differences in mean SIPs across different land use/cover types. Sites with shelterbelts of *Populus L.* had the highest IIR, SIR and the highest Ks, behind shrub lands, agricultural roads, croplands, grasslands and forested sites. Pair wise comparison was done using Spearman correlation analysis and results reveal that SIPs have high correlation with the characteristic of the soil and vegetation data. The variations in SIPs observed across LUC/LC types were associated with changes in soil texture, field capacity and root mass density as these parameters explained 79.36% of mean SIP variance.

These parameters are directly related to the size of bedrock depressions affecting water infiltration into the soil as well as determining the spatial distribution of rainfall in the KRDS areas. Thus, it is of special scientific relevance to analyse the capacity of the trough valleys' dip and anti-dip slopes to infiltrate the soil.

To this end, this study has the following objectives: Gan et al.(2023) performed this study conducted a comprehensive assessment of soil infiltration capacity on dip and anti-dip slopes under various land use types using the cutting ring infiltration method. The key findings are as follows: i) Dip slopes exhibited higher bulk density and pH but lower soil water content, capillary porosity, and soil organic carbon compared to anti-dip slopes ($p < 0.05$). Among all land use types, grassland demonstrated the highest infiltration rate, surpassing that of farmland, forest land, urban land, and abandoned land, ii) Bulk density and total soil porosity were identified as key indicators of soil infiltration properties for both dip and anti-dip slopes, iii) Based on variability measures (R^2), the commonly used experiential model was the most suitable for explaining soil infiltration rate behaviour, iv) When considering the interactions of usable soil depth, soil moisture, and vegetation cover, grassland on both dip and anti-dip slopes showed higher soil infiltration capacity and organic matter content compared to other vegetated land use types. However, these values were lower than those observed in abandoned land without vegetation.

NARESHBHAI (2022) was done a field experiment during summer season of 2021. The samples were collected from different talukas of Saurashtra region and tested at the Department of Soil Science and Agricultural Chemistry College of Agriculture Junagadh Agricultural University Junagadh. From the analyzed data set it was also found that the Saurashtra region soils had a moderate position as far as their organic carbon content was concerned with an average of 0.57%. Of the 25 districts, the highest OF content was in Porbandar with 0.82% followed by Devbhumi Dwarka 0.75%, and the lowest was in Surendranagar with 0.44%. Of the soils in the region, a large proportion was calcareous and had an alkaline reaction. The pH2.5 of the soil in the region was calculated to be on an average of 8 on the pH scale. The pH2.5 values for Rajkot, Porbandar and Junagadh was the lowest and that for Amreli was the highest. Soil samples had the mean electrical conductivity (EC2.5) of 0.53 dS/m. Morbi and Porbandar districts had the lowest and highest EC2.5, respectively. Assuming the nutrient index values, it was observed that, Porbandar, Gir-Somnath, and Devbhoomi Dwarka were the highest potential districts regarding very high organic carbon. However, the organic carbon in Bhavnagar, Amreli, Rajkot and Surendranagar districts is very low compared to other districts of Saurashtra region.

Wang et al., (2024) the study tested two quantitative SIPS, the IIR and the Ks, in five depths in pine, oak, and bamboo stands at 0–10, 10–20, 20–30, 30–40, and 40–50 cm. Using the physical properties of SIPs as variables and employing SEM, a method was established to determine the major physical properties affecting the SIPs and their pathways. The results revealed that IIR and Ks values across the soil profile followed the order: pine > oak > bamboo. STP, SFC, CMC, SWC and ISWC were significant and positively related with the SIPs. On the other hand, the soil bulk density had an inverse relationship with the SIPs. Furthermore, upon SEM analysis it was discerned that SBD and sand content were negative to infiltration of the soil whereas STP was positive. It also noted that SBD was associated with STP through the soil texture and that SWC as well as the SIPs are dependent on SBD but not independently of the soil texture. In general, these findings are important for simulating the basic elements in subsurface hydrology in forest ecosystems, and informing subsequent forest management measures for exploitation or conservation.

Peng et al., (2024) Such factors as pore characteristic, water infiltration rates and some properties of the soil, this research sought to determine the effect of the long-term cultivation on the northeast Mollisol region of China. The study considered croplands that were established 20, 40, 60, and 100 years ago, and the forest reference site (FR). These changes were determined after long-term cultivation using a mini disk infiltrometer and x-ray CT scanning on samples collected from 0–100 cm depths. Consequently, pore characteristics of significance cover; total porosity (TP), pore number (PN), pore size distribution, mean shape factor (MSF), fractal dimension (FA), pore anisotropy (DA) and Euler number (EN). Furthermore, some infiltration parameters such as mean infiltration rates (IR), initial infiltration rates (IIR), stable infiltration rates (SIR) and saturated hydraulic conductivity (Ks) were described and calculated. Significant differences were observed: SOC was significantly reduced in croplands than the forest soil but BD and

MWD were considerably enhanced in cropland. With long-term cultivation, the plaque shape and size distribution of soil pores were changed, which reduced the microporosity (> 500 μm) and elongated pores. These changes reduced the porosity of the soil and give an evidence to the detrimental effect that resulted from an elongated time of cultivation on aspect of the structure and functionality of the soil pore.

METHODOLOGY

STUDY AREA AND EXPERIMENTAL WORK

The proposed research examines the ingress of semi-compacted soils in Junagadh Taluka, Gujarat, India. The study area covering 680 kilometre square has been selected with variations in topographical and climate for comparing rates of infiltration and its relationship with soil parameter. The annual rainfall of Junagadh Taluka varies from 800 to 1200 mm depending on the year, it plays a pivotal role in changing the status of soil moisture and infiltration rate. The region consisted of 71 villages under 51 taluka panchayats, which shows a decentralized rural administration. The patterns of land uses in the area includes Agricultural land, Grazing fields, and Forest and the land characteristics recorded include semi-compacted land.

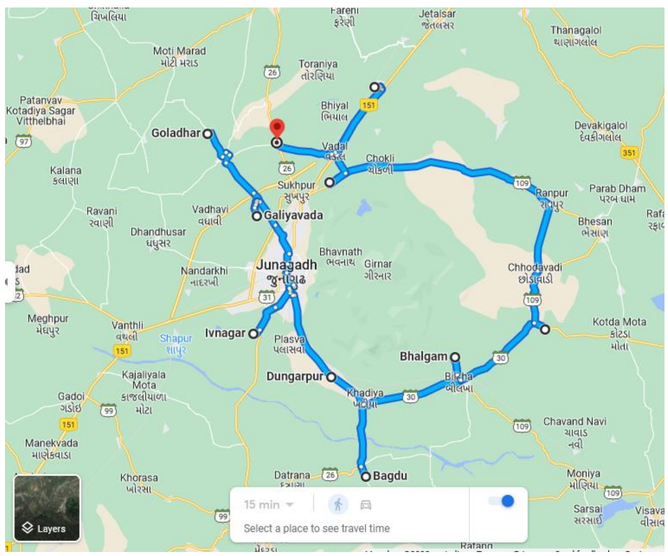

Figure 1: Location Map of Study Area

The experimental research was confined to 24 blocks in Table 1 within Junagadh Taluka to study the infiltration and its factors under different types of soil and land use and is shown in fig. 1. Field measurements were characterized through field measurements using the Double Ring Infiltrometer, ensuring standardized and accurate data collection. Analytical surveys of soil samples regarding the effects of some physical characteristics including texture, porosity, and bulk density of the infiltration rates were also conducted. Measurement conditions were standardized during data collection, taking into account pre-existing aspects, such as the initial texture of the ground, hydrological precipitation, and the surface. It is hoped that this extensive and elaborate study will assist in gains and understandings of hydrological behaviour of semi-compacted soils and support relevant water and soil resource management strategies in the region. The satellite view and soil variations are given in Figure. 2 and Figure. 3.

Table 1: List of 24 Selected Blocks

Sr.no	*Village*	*Sr.no*	*Village*
1	Khadiya	13	Vadhavi
2	Toraniya	14	Makhiyala

3	Ivnagar	15	Sukhpur
4	Plasva	16	Bilkha
5	Galiyavada	17	Bagdu
6	Valasimdi	18	Bhalgam
7	Majevdi	19	Nava Pipliya
8	Goladhar	20	Mandlikpur
9	Patrapsar	21	Bamangam
10	Dungurpur	22	Bhavnath
11	Padariya	23	Vadal
12	Khalilpur	24	Choki

Figure 2: Satellite View of Selected Area

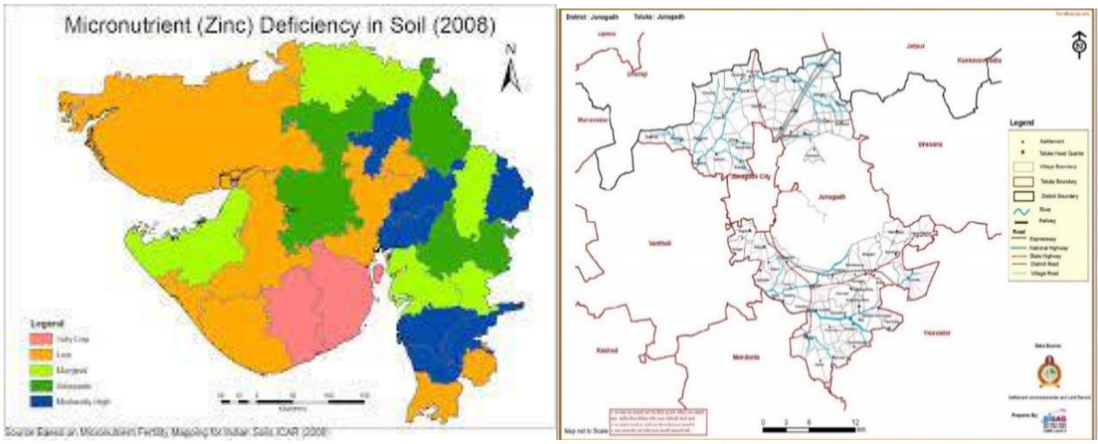

Figure 3: Micronutrient Deficiency Map of Soil

MEASUREMENT OF INFILTRATION

The infiltration rate of soil was determined using the Double Ring Infiltrometer method, following the guidelines provided by the Indian Standard Code IS 2720 (Part 28): 1986. This standard provides the method for determining water infiltration rates into soil using the double ring infiltrometer. The device utilised in this study had an outer circle of diameter 350 mm with an inner circle of diameter 200 mm and the height of both the circles was 400 mm. Hence the selection of the Double Ring Infiltrometer to which the following advantages may be attributed; The DRI is relatively simpler but sturdier and cheaper than other more complex styles of infiltrometer that are available in the market. The idea of using the double ring infiltrometer is to reduce losses from lateral flow, which is always an inherent problem when using the single ring infiltrometer. In the double ring method, the outer ring contains lateral movement and thus infiltration mainly occurs in the upward direction. The infiltration flow geometry depends on variable including the water column height of the rings, initial soil moisture content, the ring burial depth and the inherent characteristics of the medium including porosity, bulk density, and the texture.

The steps included in the experimental procedure were the site preparation on which the vegetation and debris on the ground were removed to prepare level ground for testing. The first was to securely insert each inner and outer ring into the soil to an approximate depth of 100 mm, before orientating the rings vertically so as to cause least disruption. Both rings were filled with water to ensure similar water level for both, thereby minimizing lateral flow: the depth of the water was taken. In monitoring of the inner ring, a graduated scale was used to record the water level drop at every five minutes while in the outer ring, care was taken to ensure that water level was constant and external interference was kept off. Data collection process was done up to the point of achieving steady rate of infiltration and that means that the soil was almost saturated. The infiltration rate was computed and determined by the following eqn. (1),

$$I = \frac{h_1 - h_2}{t_2 - t_1} \tag{1}$$

where h_1 and h_2 show water levels at times t_1 and t_2, respectively.

The double ring infiltrometer method was adopted because it consistently produces satisfactory results irrespective of the type of soils and land use and it is given in Figure. 4. Including its capacity to reduce lateral flow and guarantee accurate vertical infiltrations in addition to its simplicity and low cost of acquisition.

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 1, 2025
https://www.theaspd.com/ijes.php

Figure 4: Double Ring Infiltrometer

RESULTS AND DISCUSSION

The infiltration rate (IR) of soil in the field was determined using double- ring infiltrometer over 24 blocks in Junagadh Taluka, wherein the recorded data is given in Tables 2 to 25. The findings show that infiltration rates vary spatially owing to environmental conditions and soil characteristics and Pulse 1 land-use categories. H2 Higher infiltration rates were recorded in blocks with cracked loose block structure within which well-developed vegetation cover was dominant while low infiltration rates were recorded in compacted block in areas that were experiencing intensive agricultural activities. The measurements show that the temperature, rainfall and wind speed during the experimental period were important factors. Higher temperatures in 2024 than in 2023 have led to evaporation rates, and consequently the soil moisture content and, possibly, the infiltration rates. Wind speed including exposed areas, accelerated surface evaporation, impacting initial infiltration rates. Such environmental variables call for incorporation of time varying climatological conditions in infiltration studies of the soil. The basic map or map coordinates supplemented by the spatial distribution analysis revealed influences of infiltration rates of blocks with sandy loam soil textures and moderate topographical conditions. This observation worked well with the hydrological conditions depicted by significantly slower infiltration rates of soils having clayey layer or soils with low permeability. Tables 2 to 25 also substantiate these observations in tabular form contained infiltration measurements and again show patterns indicating high initial infiltration rates, followed by a constant slow increase or even a decrease as a result of either soil saturation or changes in hydraulic gradient. The data also outline the importance of other aspects of soil management. Paddock with good agricultural management like mulching and minimum tillage had better infiltration rates than paddocks that had intensive tillage or grazing. These observations provide useful information in the sustainable management of soil water and the importance of the approaches that help to overcome the problem of high variability of properties of soil and water resource due to the effect of environmental factors. The spatial and temporal data analyses presented in Tables 2 to 25 and Fig 5 to Fig 10 provide a strong basis for investigating infiltration processes in various landscapes.

Table 2: Infiltration Rate Measurement Outcomes from Block 1

Block: 1	***Location: Khadiya***	***Date:09/03/24, time: 2:30 pm***	***Wind speed: 13 kmh***	***Map coordinate: 21.5871° N, 70.2565° E***	***Temperature: 34° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.2	12.7	1.5	89.82	1.5

2		12.0	0.7	41.92	2.2
20	14.7	13.1	1.6	19.28	14
25		11.8	1.3	15.66	15.3
55	14.3	13.1	1.2	14.46	23.3
60		12.6	0.5	6.02	23.8
65		12.1	0.5	6.02	24.3
70		11.7	0.5	6.02	24.8

Table 3: Infiltration Rate Measurement Outcomes from Block 2

Block: 2	***Location: toraniya***	***Date:09/03/24, time: 04:45 pm***	***Wind speed: 13 kmh***	***Map coordinate: 21.4382° N, 70.5455° E***	***Temperature: 33° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.8	12.9	1.9	113.77	1.9
2		11.8	1.1	65.87	3
30	15	14	1	12.05	14.9
35		13.5	0.5	6.02	15.4
65	14.7	14.3	0.4	4.82	18.8
70		13.8	0.4	4.82	19.2
75		13.5	0.4	4.82	19.6

Table 4: Infiltration Rate Measurement Outcomes from Block 3

Block: 3	***Location: IVNAGAR***	***Date: 17/3/24, time: 09:30 am***	***Wind speed: 12 kmh***	***Map coordinate: 21.5025°N 70.4182°E***	***Temperature: 32° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.3	14.2	1.1	65.87	1.1
2		13.3	0.9	53.89	2
7	15	14.1	0.8	24.24	5.2

9		13.4	0.8	24.24	6
25	15.2	14.8	0.4	4.82	9.1
30		14.4	0.4	4.82	9.5
35		13.9	0.5	6.02	9.9
40		13.6	0.3	3.61	10.4
45		13.4	0.2	2.41	10.7
50		13.2	0.2	2.41	10.9
55		13	0.2	2.41	11.1
60		12.8	0.2	2.41	11.3

Table 5: Infiltration Rate Measurement Outcomes from Block 4

Block: 4	***Location: palasva***	***Date: 17/3/24, time: 3:30 pm***	***Wind speed: 12 kmh***	***Map coordinate: 21.50245°N 70.41795°E***	***Temperature: 35° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.6	13	1.6	95.81	1.6
2		11.9	1.2	71.86	2.8
15	14.2	13.3	0.9	27.27	11.3
20		12.5	0.8	9.64	12.1
40	14.5	14.1	0.4	4.82	14.7
45		13.6	0.5	6.02	15.2
50		13.2	0.4	4.82	15.6
55		12.8	0.4	4.82	16

Table 6: Infiltration Rate Measurement Outcomes from Block 5

Block: 5	***Location: GALIYAVADA***	***Date: 23/03/24, time: 4:30 pm***	***Wind speed: 17 kmh***	***Map coordinate: 21.3349°N 70.2633°E***	***Temperature: 35° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)

1	14.8	13.2	1.6	95.81	2.4
2		11.7	1.5	89.82	3.9
7	14.3	13	1.3	39.39	8.9
9		12.1	0.9	27.27	9.8
15	14.5	13.8	0.7	21.21	11.9
20		13	0.8	9.64	12.7
25		12.4	0.6	7.23	13.3
30		11.9	0.5	6.02	13.8
35		11.3	0.6	7.23	14.4
40		10.9	0.4	4.82	14.8
45		10.6	0.3	3.61	15.1
50		10.4	0.2	2.41	15.3
55		10.2	0.2	2.41	15.5
60		10.1	0.2	2.41	15.7

Table 7: Infiltration Rate Measurement Outcomes from Block 6

Block: 6	***Location: valasimdi***	***Date: 24/3/24, time: 10:40 am***	***Wind speed: 18 kmh***	***Map coordinate: 21.6309° N, 70.4224° E***	***Temperature: 36° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.2	13.6	1.6	95.81	1.6
2		12.1	1.5	89.82	3.1
20	14.8	13.9	1.1	13.25	14.3
25		13.1	0.8	9.64	15.1
60	14.4	13.9	0.5	6.02	19.9
65		13.3	0.6	7.23	20.5
70		13	0.4	4.82	20.9
75		12.6	0.4	4.82	21.3
80		12.2	0.4	4.82	21.7

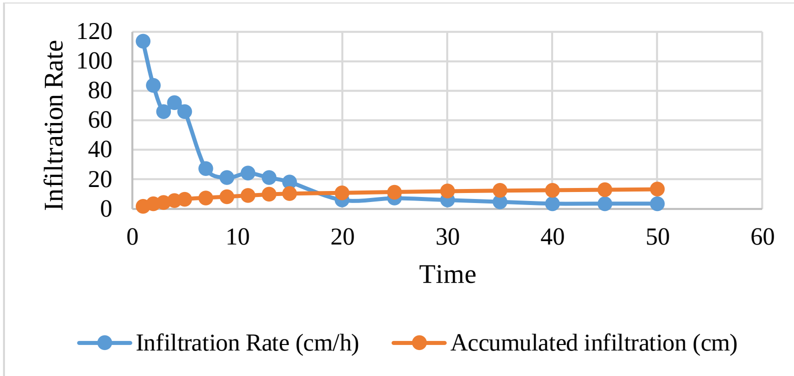

Figure 5: Infiltration Rate of Minimum Value

Table 8: Infiltration Rate Measurement Outcomes from Block 7

Block: 7	*Location: Majevdi*	*Date: 30/3/24, time: 04:30 pm*	*Wind speed: 12 kmh*	*Map coordinate: 21.6069° N, 70.4067° E*	*Temperature: 37° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.3	13.2	0.9	53.89	0.9
2		12	0.8	47.90	1.7
15	14.1	13.4	0.5	15.15	8.6
20		12.7	0.7	8.43	9.3
40	14.5	14	0.5	6.02	11.5
45		13.6	0.4	4.82	11.9
50		13.3	0.3	3.61	12.2
55		12.9	0.4	4.82	12.6
60		12.6	0.3	3.61	12.9
65		12.4	0.2	2.41	13.1
70		12.2	0.2	2.41	13.3
75		12	0.2	2.41	13.5

Table 9: Infiltration Rate Measurement Outcomes from Block 8

Block: 8	*Location: Goladhar*	*Date: 31/3/24, time: 03:30 pm*	*Wind speed: 13 kmh*	*Map coordinate: 21.6248° N, 70.3956° E*	*Temperature: 37° c*

Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.6	12.7	1.9	113.77	1.9
2		11.3	1.4	83.83	3.3
15	14.5	13.9	0.6	18.18	10.4
20		13.4	0.5	6.02	10.9
40	14.6	14.3	0.3	3.61	12.7
45		14	0.3	3.61	13
50		13.7	0.3	3.61	13.3

Table 10: Infiltration Rate Measurement Outcomes from Block 9

Block: 9	***Location: Patrapsar***	***Date: 31/3/24, time: 5:05 pm***	***Wind speed: 13 kmh***	***Map coordinate: 21.5793° N, 70.3780° E***	***Temperature: 37° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.5	13.2	2.3	137.72	2.3
2		11.3	1.9	113.77	4.2
20	15	13.9	1.1	13.25	17.5
25		12.7	1.2	14.46	18.7
50	15.3	14.7	0.6	7.23	22.4
55		14.1	0.6	7.23	23
60		13.5	0.6	7.23	23.6

Table 11: Infiltration Rate Measurement Outcomes from Block 10

Block: 10	***Location: Dungurpur***	***Date: 7/4/24, time: 9:15am***	***Wind speed: 12 kmh***	***Map coordinate: 21.4454° N, 70.4938° E***	***Temperature: 33° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.1	12.9	1.2	71.86	1.2

2		11.7	1.2	71.86	2.4
15	14.3	13.7	0.6	18.18	8.8
20		13.2	0.5	6.02	9.3
25		12.8	0.4	4.82	9.7
40		11.6	0.3	3.61	10.9
45		11.4	0.2	2.41	11.1
50		11.3	0.1	1.20	11.2
55		11.2	0.1	1.20	11.3
60		11.1	0.1	1.20	11.4

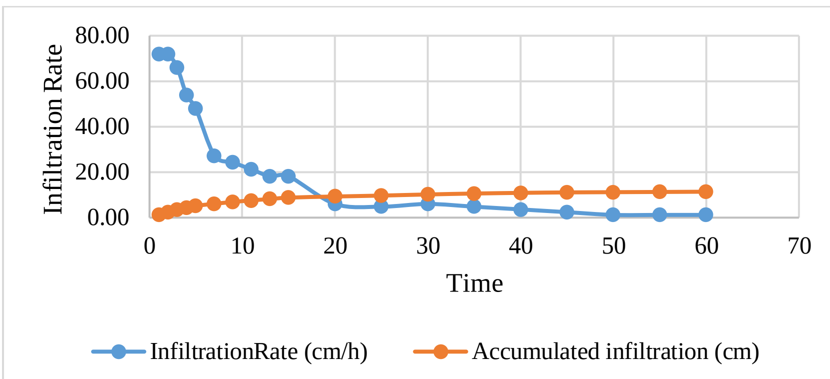

Figure 6: Infiltration Rate of Lowest Value

Table 12: Infiltration Rate Measurement Outcomes from Block 11

Block: 11	*Location: Padariya*	*Date: 7/4/24, time: 05:10 pm*	*Wind speed: 12 kmh*	*Map coordinate: 21.4665° N, 70.4737° E*	*Temperature: 33° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.2	12.7	1.5	89.82	1.5
2		11.3	1.4	83.83	2.9
7	14.5	13.6	0.9	27.27	7.2
9		12.4	0.8	24.24	8
15	14.4	13.6	0.8	24.24	10.5
20		12.9	0.7	8.43	11.2

35		11.4	0.4	4.82	12.7
40		11.1	0.3	3.61	13
45		10.9	0.2	2.41	13.2
50		10.7	0.2	2.41	13.4
55		10.5	0.2	2.41	13.6

Table 13: Infiltration Rate Measurement Outcomes from Block 12

Block: 12	*Location: Khalilpur*	*Date: 14/4/24, time: 10:00 am*	*Wind speed: 14 kmh*	*Map coordinate: 21.4665° N, 70.4737° E*	*Temperature: 35° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.1	12.4	1.7	101.80	1.7
2		10.9	1.5	89.82	3.2
15	14.2	13.2	1	30.30	12.8
20		12.3	0.9	10.84	13.7
40	14.3	13.7	0.6	7.23	16.5
45		13.2	0.5	6.02	17
50		12.7	0.5	6.02	17.5
55		12.2	0.5	6.02	18

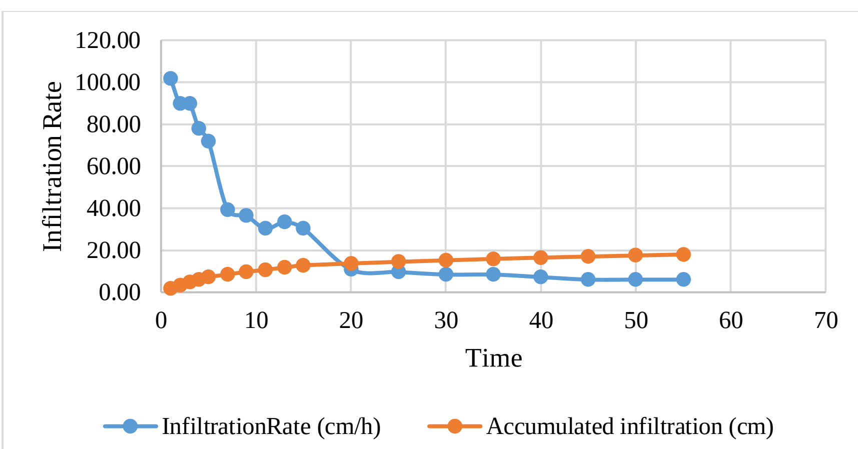

Figure 7: Infiltration Rate of Minimum Value

Table 14: Infiltration Rate Measurement Outcomes from Block 13

Block: 13	***Location: Vadhavi***	***Date: 14/4/24, time: 05:10 pm***	***Wind speed: 14 kmh***	***Map coordinate: 21.5639° N, 70.3977° E***	***Temperature: 34° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	13.9	11.7	2.2	131.74	2.2
2		9.7	2	119.76	4.2
15	14.3	13.5	0.8	24.24	13.8
20		12.8	0.7	8.43	14.5
40	14.2	13.8	0.4	4.82	16.6
45		13.4	0.4	4.82	17
50		13.1	0.3	3.61	17.3
55		12.8	0.3	3.61	17.6
60		12.5	0.3	3.61	17.9

Table 15: Infiltration Rate Measurement Outcomes from Block 14

Block: 14	***Location: Makhiyala***	***Date: 21/4/24, time: 09:05 am***	***Wind speed: 15 kmh***	***Map coordinate: 21.6186° N, 70.4506° E***	***Temperature: 31° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.1	12.9	2.2	131.74	2.2
2		10.9	2	119.76	4.2
15	14.9	13	0.9	27.27	15.2
20		12.2	0.8	9.64	16
40	14.6	14	0.6	7.23	18.8
45		13.5	0.5	6.02	19.3
50		13	0.5	6.02	19.8
55		12.5	0.5	6.02	20.3
60		12	0.5	6.02	20.8

Table 16: Infiltration Rate Measurement Outcomes from Block 15

Block: 15	*Location: Sukhpur*	*Date: 21/4/24, time: 04:45 pm*	*Wind speed: 15 kmh*	*Map coordinate: 21.5821° N, 70.4663° E*	*Temperature: 35° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14	11.7	2.3	137.72	2.3
2		9.5	2.2	131.74	4.5
15	14.3	12.9	1.2	36.36	18.6
20		11.8	1.1	13.25	19.7
40	14.1	13.3	0.8	9.64	23.6
45		12.4	0.9	10.84	24.5
55		10.9	0.7	8.43	26.1
60		10.2	0.7	8.43	26.8
65		9.5	0.7	8.43	27.5
70		8.8	0.7	8.43	28.2

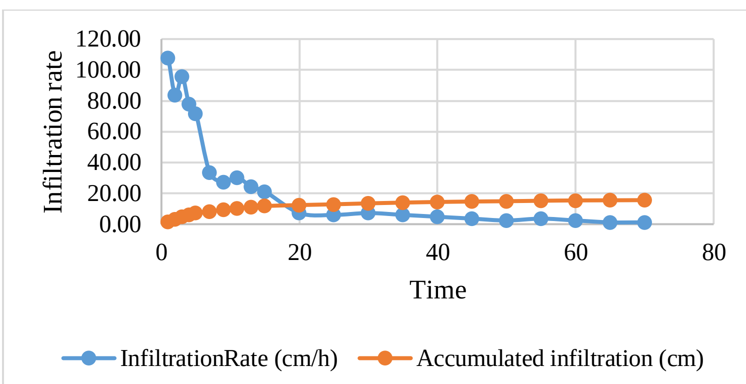

Figure 8: Infiltration Rate of Maximum Value

Table 17: Infiltration Rate Measurement Outcomes from Block 16

Block: 16	*Location: Bilkha*	*Date: 27/4/24, time: 04: 50 pm*	*Wind speed: 12 kmh*	*Map coordinate: 21.4404° N, 70.5949° E*	*Temperature: 34° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)

1	14.3	12.5	1.8	107.78	1.8
2		11.1	1.4	83.83	3.2
15	14.4	13.7	0.7	21.21	11.8
20		13.1	0.6	7.23	12.4
40	14.5	14.1	0.4	4.82	14.4
55		13.3	0.3	3.61	15.2
60		13.1	0,2	2.41	15.4
65		13	0.1	1.20	15.5
70		12.9	0.1	1.20	15.6
75		12.8	0.1	1.20	15.7

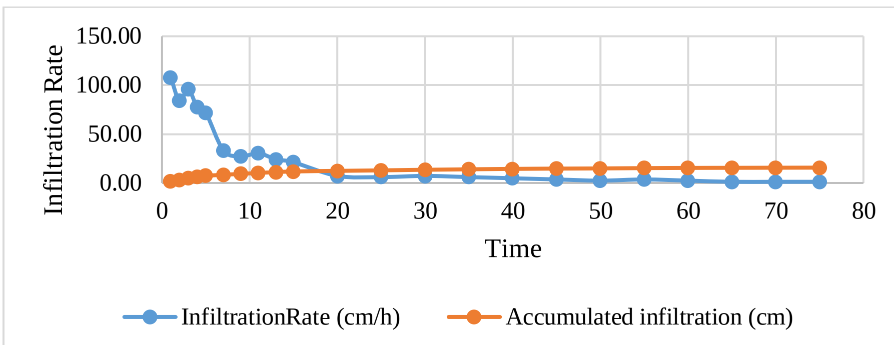

Figure 9. Infiltration Rate of Lowest Value

Table 18: Infiltration Rate Measurement Outcomes from Block 17

Block: 17	***Location: Bagdu***	***Date: 28/4/24, time: 09:45 am***	***Wind speed: 11 kmh***	***Map coordinate: 21.3715° N, 70.5205° E***	***Temperature: 34° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.9	13.7	1.8	107.78	1.8
2		12.3	1.4	83.83	3.2
15	14.9	13.9	1	30.30	12.7
20		13	0.9	10.84	13.6
40	14.5	13.8	0.7	8.43	16.8
45		13	0.8	9.64	17.6
55		11.7	0.6	7.23	18.9

60		11.1	0.6	7.23	19.5
65		10.5	0.6	7.23	20.1
70		9.9	0.6	7.23	20.7

Table 19: Infiltration Rate Measurement Outcomes from Block 18

Block: 18	***Location: Bhalgam***	***Date: 4/5/24, time: 4:10 pm***	***Wind speed: 16 kmh***	***Map coordinate: 21.4600° N, 70.5919° E***	***Temperature: 37° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.8	12.7	2.1	125.75	2.1
2		10.9	1.9	113.77	4
7	15	13.4	1.6	48.48	10.6
9		12.1	1.3	39.39	11.9
20	15.2	14.1	0.9	10.84	16.5
25		13.1	1	12.05	17.5
35		11.4	0.8	9.64	19.2
40		10.6	0.8	9.64	20
45		9.8	0.8	9.64	20.8
50		9	0.8	9.64	21.6

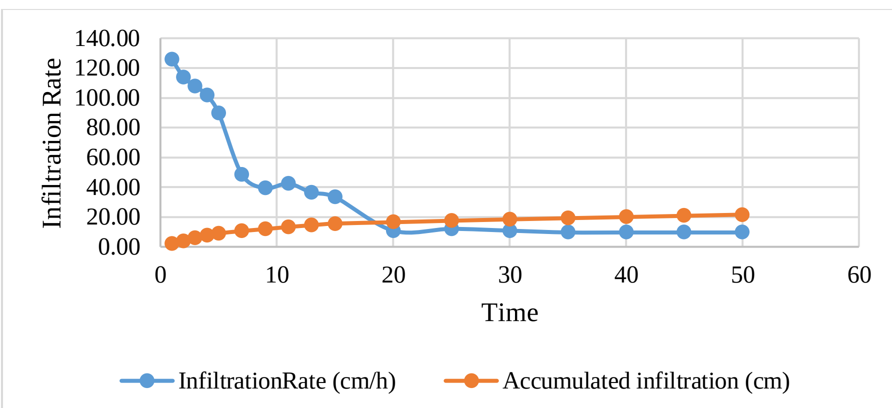

Figure 10: Infiltration Rate of Maximum Value

Table 20: Infiltration Rate Measurement Outcomes from Block 19

Block: 19	***Location: Nava Pipliya***	***Date: 11/5/24, time: 3:30 pm***	***Wind speed: 14 kmh***	***Map coordinate: 21.44575°N 70.61445°E***	***Temperature: 38° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	13.8	12.1	1.7	101.80	1.7
2		10.5	1.6	95.81	3.3
15	14.1	12.9	1.1	33.33	14.6
20		11.8	1.1	13.25	15.7
45	14	13.3	0.7	8.43	20
50		12.7	0.6	7.23	20.6
55		12.3	0.5	6.02	21.1
60		11.8	0.5	6.02	21.6
65		11.3	0.5	6.02	22.1

Table 21: Infiltration Rate Measurement Outcomes from Block 20

Block: 20	***Location: Madlikpur***	***Date: 12/5/24, time: 04:15pm***	***Wind speed: 14 kmh***	***Map coordinate: 21.3493° N, 70.5317° E***	***Temperature: 37° c***
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.6	12	2.6	155.69	2.6
2		9.7	2.3	137.72	4.9
15	14.1	13	1.1	33.33	17
20		12.1	0.9	10.84	17.9
40	14.2	13.7	0.7	8.43	20.9
55		12.6	0.5	6.02	22
60		12.1	0.5	6.02	22.5
65		11.6	0.5	6.02	23

Table 22: Infiltration Rate Measurement Outcomes from Block 21

Block: 21	*Location: Bamangam*	*Date: 17/5/24, time: 05:30 pm*	*Wind speed: 15 kmh*	*Map coordinate: 21.5890° N, 70.4919° E*	*Temperature: 34° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.7	12.6	2.1	125.75	2.1
2		10.5	1.9	113.77	4
7	15.1	13.8	1.3	39.39	10.1
9		12.6	1.2	36.36	11.3
15	15	14	1	30.30	14.2
30		11.9	0.6	7.23	16.3
35		11.3	0.6	7.23	16.9
40		10.7	0.6	7.23	17.5
45		10.1	0.6	7.23	18.1

Table 23: Infiltration Rate Measurement Outcomes from Block 22

Block: 22	*Location: Bhavnath*	*Date: 18/5/24, time: 09:30 am*	*Wind speed: 15 kmh*	*Map coordinate: 21.5334° N, 70.5012° E*	*Temperature: 36° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.3	13.1	2.2	131.74	2.2
2		11	2.1	125.75	4.3
7	15.1	13.6	1.5	45.45	10.6
9		12.2	1.4	42.42	12
15	15.2	14.1	1.1	33.33	15.8
25		12.4	0.8	9.64	17.5
35		11.1	0.6	7.23	18.8
40		10.5	0.6	7.23	19.4
45		10	0.5	6.02	19.9

50		9.5	0.5	6.02	20.4
55		9	0.5	6.02	20.9

Table 24: Infiltration Rate Measurement Outcomes from Block 23

Block: 23	*Location: Vadal*	*Date: 19/5/24, time: 07:30 am*	*Wind speed: 15 kmh*	*Map coordinate: 21.6113° N, 70.4970° E*	*Temperature: 33° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.2	12.1	2.1	125.75	2.1
2		10.4	1.7	101.80	3.8
7	14.5	13.3	1.2	36.36	9.8
9		12	1.3	39.39	11.1
15	14.3	13.5	0.8	24.24	13.9
20		12.6	0.9	10.84	14.8
30		11.2	0.6	7.23	16.2
35		10.8	0.4	4.82	16.6
40		10.4	0.4	4.82	17
45		10	0.4	4.82	17.4

Table 25: Infiltration Rate Measurement Outcomes from Block 24

Block: 24	*Location: Choki*	*Date: 19/5/24, time: 09:45 am*	*Wind speed: 15 kmh*	*Map coordinate: 21.6619° N, 70.5302° E*	*Temperature: 36° c*
Time (Min)	Initial water level (cm)	Final water level (cm)	Fall in water level (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.2	12.8	2.4	143.71	2.4
2		10.5	2.3	137.72	4.7
15	14.9	14.1	0.8	24.24	14.3
20		13.5	0.6	7.23	14.9
40	14.5	14	0.5	6.02	17
45		13.7	0.3	3.61	17.3

50		13.4	0.3	3.61	17.6
55		13.1	0.3	3.61	17.9
60		12.8	0.3	3.61	18.2

The infiltration rate measurements of 2023 and 2024 presented in the Table 26 show seasonal variations and varied degree of infiltration rates among the selected villages of Junagadh Taluka. The contour map of infiltration rate also showed high increases such as 2.38 cm/h to 6.02 cm/h of Khadiya and 1.20 cm/h to 4.82 cm/h of Toraniya which depict the improve soil permeability or water management. On the other hand, there was a reduction in download speed in some of the villages as a result of compacted soil or other factors like, Makhiyala from 7.23cm/h to 6.02 cm/h, Bamangam from 8.43 cm/h to 7.23 cm/h basically. In other villages such as Ivnagar Bilkha and Bagdu the results showed no significant alteration in the rates of infiltration suggesting that the area's soil and environmental conditions are stationary. In general, there was increased infiltration rates for majority of the villages in the study area; however, some revealed a decrease or stagnated infiltration, an indication that specific local factors that have an impact on infiltration rates include texture, compaction, and variations in rainfall distribution.

Table 26 showing the comparison of infiltration rates of each village for the years 2023 & 2024 varies greatly and reveals the following: When examining the infiltration rates the highest positive changes were observed with Khadiya and Toraniya demonstrating 3.64 cm/h and 3.62 cm/h, respectively: all of which suggest better soil management has improved water absorption. Similarly, moderate increase across other villages including Plasva, Valasimdi and Patrapsar having estimates varying between 1.20 cm/h and 2.41 cm/h only. On the other hand, the infiltration rates in some of the villages has decreased; for example, Padariya (-2.41 cm/h), Makhiyala (-1.21 cm/h), and Bamangam (-1.20 cm/h). Ubiquitous bias does not affect the infiltration rates of several villages such as Ivnagar, Dungurpur, Bagdu etc., throughout the study, which reveals that there are no variations in the soil properties and environmental conditions.

Table 26: Comparison Analysis Change in Infiltration Rate

Sr.no	***Village***	***Infiltration Rate 2023 (cm/h)***	***Infiltration Rate 2024 (cm/h)***	***Change in Infiltration Rate (cm/h)***
1	Khadiya	2.38	6.02	3.64
2	Toraniya	1.20	4.82	3.62
3	Ivnagar	2.41	2.41	0.00
4	Plasva	3.61	4.82	1.21
5	Galiyavada	3.61	2.41	-1.20
6	Valasimdi	2.41	4.82	2.41
7	Majevdi	1.20	2.41	1.21
8	Goladhar	2.41	3.61	1.20
9	Patrapsar	4.82	7.23	2.41
10	Dungurpur	1.20	1.20	0.00
11	Padariya	4.82	2.41	-2.41
12	Khalilpur	3.61	6.02	2.41

13	Vadhavi	3.61	3.61	0.00
14	Makhiyala	7.23	6.02	-1.21
15	Sukhpur	6.02	8.43	2.41
16	Bilkha	1.20	1.20	0.00
17	Bagdu	7.23	7.23	0.00
18	Bhalgam	8.43	9.64	1.21
19	Nava Pipliya	4.82	6.02	1.20
20	Mandlikpur	4.82	6.02	1.20
21	Bamangam	8.43	7.23	-1.20
22	Bhavnath	4.82	6.02	1.20
23	Vadal	6.02	4.82	-1.20
24	Choki	3.61	3.61	0.00

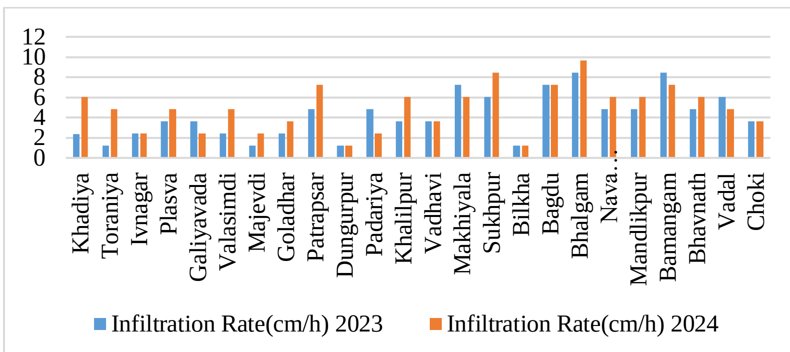

Figure 11. Comparative Analysis of Infiltration Rates

Table 27: Calculations of Water Content for Five Villages

Particulars	*Ivnagar*	*Sukhpur*	*vadal*	*Dungurpur*	*Makhiyala*
Weight of empty container (W1) gm	45	45	45	45	45
	45	45	45	45	45
Weight of container + wet soil (W2) gm	245	245	240	242	239
	245	245	240	242	239
Weight of container +dry soil (W3) gm	238	235	229	235	225
	239	233	228	238	224
Water content,	3.63%	5.13%	5.98%	3.68%	7.78%
W= (W2-W3)/(W3-	3.09%	6.38%	6.56%	2.07%	7.54%

W1)*100%					
Average water content	3.36%	5.75%	6.27%	2.883%	7.66%

Table 28: Calculations of Density for Five Villages

Particulars	*Ivnagar*	*Sukhpur*	*vadal*	*Dungurpur*	*Makhiyala*
Weight of empty cutter (W1), gm	1272	1272	1272	1272	1272
	1272	1272	1272	1272	1272
Weight of cutter + Wet soil (W2), gm	3165	3113	3103	3189	3101
	3199	3178	3098	3196	3094
Volume of core cutter (Vc) cm^3	1000	1000	1000	1000	1000
	1000	1000	1000	1000	1000
Weight of wet soil (W3), (W2 – W3),gm	1893	1841	1831	1917	1829
	1927	1906	1826	1924	1822
Field bulk density ϒb (gm/cm^3) = (W3)/Vc	1.89	1.84	1.83	1.92	1.82
	1.93	1.91	1.82	1.92	1.82
Average of bulk density	1.91	1.88	1.825	1.92	1.82
Water Content (W)	0.0336	0.0575	0.062	0.028	0.0766
Dry density ϒd (gm/cm^3) = ϒb / (1+W)	1.85	1.78	1.71	1.86	1.69

Table 29 shows the Soil characteristics include the infiltration rate in mm h^{-1} for five villages in the years 2023 and 2024, water content in g/g, bulk density in g cm^{-3} and dry density in g cm^{-3}. It revealed that IR has increased to the highest level in Sukhpur from 6.02 to 8.43 cm/h and in Vadal it has decrease from 6.02 to 4.82 cm/h. Makhiyala had the maximum percentage of water, 7.66% and minimum dry density of 1.69 gm/cm^3. These variations show that, in general, soil properties are a major determinant of infiltration processes.

Table 29: Infiltration Rate, Water Content, Bulk Density, and Dry Density of Five Village

Sr.no	*Village*	*Infiltration Rate cm/h 2023*	*Infiltration Rate cm/h 2024*	*Water content %*	*Bulk density gm/cm3*	*Dry density gm/cm3*
1	Ivnagar	2.41	2.41	3.36	1.91	1.85
2	Sukhpur	6.02	8.43	5.75	1.88	1.78
3	Vadal	6.02	4.82	6.27	1.825	1.71
4	Dungarpur	1.20	1.20	2.88	1.92	1.86
5	Makhiyala	7.23	6.02	7.66	1.82	1.69

AVERAGE CHANGE IN INFILTRATION RATE

Average change in infiltration rate apparent between 2023 and 2024 for the area of the research is about 0.855 cm/h. This indicates a general favourable trends of infiltration capacity of the soil, probably as a result of better management of the soil, rainfall distribution, or water management practices that have been implemented in some regions. The data shows an overall trend of infiltration rates improving between 2023 and 2024 on most of the villages involved. However, five villages have logged reduced attack rates, which can result from soil compaction, erosion, or poor water utilization. Furthermore, six villages show little change, presumably because their practices entail fairly efficient, although not dynamic, use of soil and land resources.

VILLAGES WITH THE LOWEST INFILTRATION RATES

2023: These villages often are established on soils with poor soil attributes such as compacted or clayey subsoils and have poor water control practices implying low infiltration values.

2024: These villages had minor enhancement in technologies applied to irrigation or land use of the region but are evidently hindered by poor innate soil issues that restrict greater advancement in infiltration rates.

VILLAGES WITH MODERATE INFILTRATION RATES

2023: The type of villages in this category was characterized by stable soil conditions the average methods of water management which enable moderate rates of infiltration.

2024: Small changes in the use of the soil and water in cultivation, as in crop rotation or minimum tillage, have been responsible for small increases, raising it moderately.

VILLAGES WITH THE HIGHEST INFILTRATION RATES

2023: The communities with optimal soil types, including sandy or well-aggregated soils and efficient water control, including rainwater collection or drip irrigation, displayed the most infiltration rates.

2024: These villages have to date sustained efficient practice which has maintained their high performance though minor decline may be seen in some instance, due to factors such as over exploitation or change in land usage.

CONCLUSION

The data implies a gradual rise of the infiltration rates in majority of villages across 2023-2024 implying enhanced practices of soil and water conservation. However, that trend is not consistent, and different villages recorded low infiltration rates due to those challenges. One of these factors is the difference in temperature between 2024 and 2023 during the experimental period. It would be expected that higher temperature led to increased rates of drying of the soil, faster rates of evaporation and changes in the permeability of the soil that led to a higher infiltration rate under some conditions. Further, it was observed that the requisite infiltration experiments in both the years were affected or benefited by the rainfall ranging between 60 to 65 inches of Junagadh district and taluka in the year 2023. In the experimental locations, favourable soil structure and layer were also equally significant. Irrigation and conservation improved methods were found more common in the villages which having high porosity, relative compaction, and crystalline structure of the soil sample collected from the study area had high infiltration rate regarding to the better water management practices. On the other hand, those that are practiced in areas with unfavourable soil conditions including compaction and or clayey types and generally less efficient practices had lower infiltration rates. These changes depicted from 2023 to 2024 show how rate of infiltration is not constant implying that by the time area with better management practices have improved then that of area with declining management practices thus degradation of the soil or change in environmental factors affects the infiltration rate. Soil factors and other management practices should be considered in determining efficient infiltration rates of water to support sustainable utilization of this resource. It therefore enhances the need to have site specific intervention strategies to overcome the phenomenon of water scarcity, including soil type, type of land use, and climate factors, ensuring sustainable water resource management.

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