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Experimental Study on Infiltration Pattern in the Soil of Junagadh (Gujarat-India)

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Abstract: Infiltration plays a pivotal role in both irrigated and rainfed agriculture, serving as a fundamental component of efficient environmental planning systems. These studies sought to model infiltration rate (IR) and assess its spatial variability within Junagadh Taluka, Gujarat, India. Employing a double-ring infiltrometer, field measurements were conducted across 24 blocks, encompassing a diverse range of soil types. The study observations revealed varying infiltration rates among villages, with rates exceeding 4.82 cm/h indicating permeable soils, while rates below 1.2 cm/h suggested compacted soils. Initial infiltration rates were uniformly high across all blocks but demonstrated a gradual decrease with successive readings. Furthermore, forested areas exhibited higher infiltration rates compared to urban and grassland regions. These findings underscore the importance of understanding infiltration dynamics for effective water management and environmental planning. A detailed information Table was developed, depicting infiltration rates across the 24 blocks, thereby providing valuable insights for decision-makers involved in hydrological processes, land-use planning, and water resource management. This study enhances the comprehension of soil-water interactions and offers practical implications for the region's sustainable agricultural practices and environmental conservation efforts.

Keywords: Double-ring infiltrometer; infiltration rate; Junagadh taluka; Gujarat; spatial variability.

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1. Introduction

The soil-water infiltration process holds pivotal importance across various fields including pedology, hydrology, drainage, hydrogeology, and irrigation systems. The capability of water to permeate soil strata is known as infiltration. A soil stratum's total capacity to absorb water from irrigation or rainfall in a given time is known as the cumulative infiltration; the velocity at which water enters the soil in a given period is known as the instantaneous infiltration rate; and the total capacity to absorb water from irrigation or rainfall in a given time is known as the infiltration rate [Anni, Cohen, et a., (2020); Wu, Cui, et al., (2021); Pahlavan-Rad, Dahmardeh, et al., (2020)]. The rate at which water seeps into the soil is determined by a variety of factors, such as the initial moisture conditions of the ground's surface, the intensity of rainfall, the temperature of the soil and water, biological activities in the soil column, the texture, porosity, and compactness of the soil, and surface cover conditions [Ren, Hong, et al., (2020); Saputra, Sari, et al., (2022); Songmin, Chunxue, et al., (2022)].

For in situ infiltration rate measurement, single or double-ring infiltrometers are frequently employed; the double-ring infiltrometer is the recommended option. The inaccuracy that could arise from lateral flow in the soil is lessened when the outer ring is used [Lewis, Amoozegar, et al. (2021); Petkov, (2021)]. When utilizing the double-ring infiltrometer, maintaining equal depths between the rings while measuring only the flow into the inner ring ensures consistency and accuracy in infiltration rate assessments. The outer ring primarily facilitates horizontal flow, minimizing its impact on the measured vertical infiltration, thereby reducing the influence of ring size variations on the results [Zhang, Li, (2020); Das, Kumar, et al., (2023)].

Junagadh, located in western Gujarat, finds itself surrounded by the Arabian Sea and dense forest areas. The soil structure here is predominantly loamy with a calcareous nature. In this region, the upper layer of soil appears relatively thin, giving way to deeper layers known as karalpan, characterized by stoniness. The soil's pH levels range from 8.0 to 8.2, indicating alkalinity. Notably, Junagadh's soil boasts a rapid drainage capacity, ensuring efficient water movement and management. As per the Report of the central water resource department Delhi, published on 20-01-2023 Friday in Gujarat Samachar of Ahmedabad edition newspaper announced that the water table goes down 1m every year in Gujarat and also in the Junagadh area. The use of groundwater is extreme in Junagadh, it is a very serious social problem, and if we do not save groundwater it affect social and economic human life very badly.To avoid this critical condition in the future we have to take advanced steps to save groundwater. Data on Infiltration patterns in Junagadhtaluka will be analyzedfor water recharge capacity. Infiltration Rate data must be helpful to find out recharge capacity and depression area where pond should be possible to recharge area in Junagadhtaluka.

Extensive research on soil infiltration rates across various slopes, climates, and land useland cover types has been conducted worldwide, but remains relatively limited within India [Xiao-yi, Zheng-an, et al., (2020); Malik, Ashraf, (2024)]. Particularly in Junagadhtaluka, no prior investigations have been undertaken in this regard. The measurement of soil infiltration for water conservation purposes represents a novel research dimension in recent years.As a result, this study has used the double-ring infiltrometer to assess field infiltration characteristics in each of the Twenty-four blocks of the Junagadh Taluka, encompassing a diverse range of soil types. The results may be used as a fundamental framework for prudent and prompt decision-making about irrigation techniques and soil preservation. Additionally, estimating the variability in the IR across different blocks or villages will help to better understand hydrological processes, which will protect better water resource planning and management.

2. Related works

The literature review has provided a comprehensive explanation of the existing methodologies explored in studying infiltration rates. The subsequent discussion outlines prior research efforts that have examined various approaches and types of infiltrometers utilized for measuring infiltration.

The research [Kumar, Chaplot, et al., (2021)] examined the spatial water infiltration characteristics in Gaya district, Bihar, India, utilizing a mini disc infiltrometer across all 24 blocks. Initial infiltration rates (IR) were observed to be high but gradually decreased over time. Forested areas showed higher cumulative IR compared to urban and grasslands, indicating the need for constructing recharge structures in blocks with above-average IR. The study provided a readily applicable map of IR for informed decision-making in hydrological processes and soil-water management, although it lacked a comprehensive collection of infiltration data.The goal of the study [Patle, (2021)] was to calculate the steady infiltration rates in paddy-growing regions in Sikkim, India, within a micro watershed. Using the double-ring infiltrometer test, the study compared observed rates with predictions from various infiltration models. Soil analysis included moisture content, bulk density, and texture. Based on the coefficient of determination, the Kostiakov model was found to be the most suitable for the micro watershed; nevertheless, it might not be relevant to paddy fields in different locations or with different characteristics. Using data from the Walnut Creek watershed in North Carolina, the study in [Bergeson, Martin, et al., (2022)] sought to evaluate soil infiltration rates in an urban watershed and compared them with rainfall-runoff models. Utilizing the Green-Ampt and Horton models alongside a random forest model, infiltration rates were estimated, with the random forest model proving more accurate. Despite discovering higher-than-expected infiltration capacities in urban soils, managing storm water remained challenging. Recommendations included disconnecting impervious surfaces and preserving urban forests to mitigate runoff and enhance infiltration. However, the random forest model's reliance on available geospatial data may have posed limitations in accuracy and coverage. In [Wei, Yang, et al., (2022)], the author explored the correlation between IR and soil moisture content in the context of rainfall infiltration. They derived a mathematical expression from the Horton equation to depict this relationship and validated it using experimental data. The equation effectively described the relationship, achieving a high R2 value in over 80% of the experiments. The relationship was primarily reliant on the initial soil moisture content, where higher initial moisture content resulted in lower initial IRs and a quicker decline as soil moisture content increased. However, the study's findings were limited by the validation data being sourced from just one soil type. In [Ebrahimian, Sample Lord, et al., (2020)], the researcher investigated the temporal and geographical fluctuations of Ksat in green storm water infrastructure (GSI) systems and compared in-situ Ksat monitoring techniques. For accurate Ksat measurements, the study assessed automated infiltration testing techniques. It suggested considering temporal changes of Ksat in GSI design and identified elements, such as temperature fluctuations, soil composition, and plant root structure, that cause Ksat variations in GSIs. However, the paper lacked extensive discussion on GSI system performance and longevity, focusing instead on Ksat variability and its field determination. In [Harisuseno, Cahya, (2020)], the researcher aimed to determine the soil infiltration rate equation through multiple linear regression based on soil properties. Using a double-ring infiltrometer, field measurements were carried out at sixteen locations to collect data. Multiple linear regression was utilized with soil properties as predictors and measured infiltration rate as the response. Statistical parameters were employed to assess the performance of the regression equations. Soil porosity was identified as the key factor influencing infiltration behavior, yet inconsistencies between measured and estimated rates imply limitations in prediction accuracy. The Study [Amami, Ibrahimi, et al., (2021)] examined how different tillage techniques influenced soil water penetration in a semiarid region of Tunisia. It compared three distinct tillage methods and assessed soil infiltration characteristics using three infiltration models. Findings indicated that moldboard plowing enhanced soil infiltration capacity in comparison to tine cultivation and no-tillage approaches. Additionally, the Philip two-term model emerged as the most suitable for representing the infiltration process in the study area. However, it is worth noting that the study may have overlooked additional tillage techniques as it only focused on three specific treatments. Due to soil compaction from overgrazing, researchers in [Panahi, Khosravi, et al., (2021)] concentrated on forecasting cumulative infiltration and IR in Western Iran using enhanced DL algorithms. They utilized six input variables to construct various input combinations for prediction. Different algorithms, including standalone CNN and optimized CNN algorithms, were compared for predictions. Results showed that optimized CNN algorithms performed better, particularly CNN-GWO. However, all models consistently underestimated cumulative infiltration and overestimated infiltration rates. The study's applicability beyond Western Iran was uncertain given its regional focus.

3. Materials and Methods

3.1 Study Area

The investigation was conducted in24 blocks around Junagadh Taluka of Gujarat state to investigate the infiltration pattern in compacted soil. Junagadh Taluka is situated in the north Saurashtra agro-climatic zone and falls between 20^0.30' to 24^0 North latitude and 69^0 to 72^0 East longitude [Pandya, Dwivedi, (2016); Patel, Bagada, (2022)]. The total geographical area of Junagadh Taluka is 68,691 hectares, and it falls under the semiarid region. The average annual rainfall in Junagadh Taluka ranges from 800 to 1,200 millimeters (31 to 47 inches). The total area of the Taluka is 680 square kilometers, comprising approximately 71 villages with 51 Taluka Panchayats. Figure 1 below illustrates the study area location-specific map, and Table 1 lists the total 24 blocks named in Junagadh Taluka for our research work.

Table 1: List of 24 blocks

Sr.no	***Village***	***Sr.no***	***Village***	***Sr.no***	***Village***	***Sr.no***	***Village***
1	Khadiya	7	Majevdi	13	Vadhavi	19	Nava Pipliya
2	Toraniya	8	Goladhar	14	Makhiyala	20	Mandlikpur
3	Ivnagar	9	Patrapsar	15	Sukhpur	21	Bamangam
4	Plasva	10	Dungurpur	16	Bilkha	22	Bhavnath
5	Galiyavada	11	Padariya	17	Bagdu	23	Vadal
6	Valasimdi	12	Khalilpur	18	Bhalgam	24	Choki

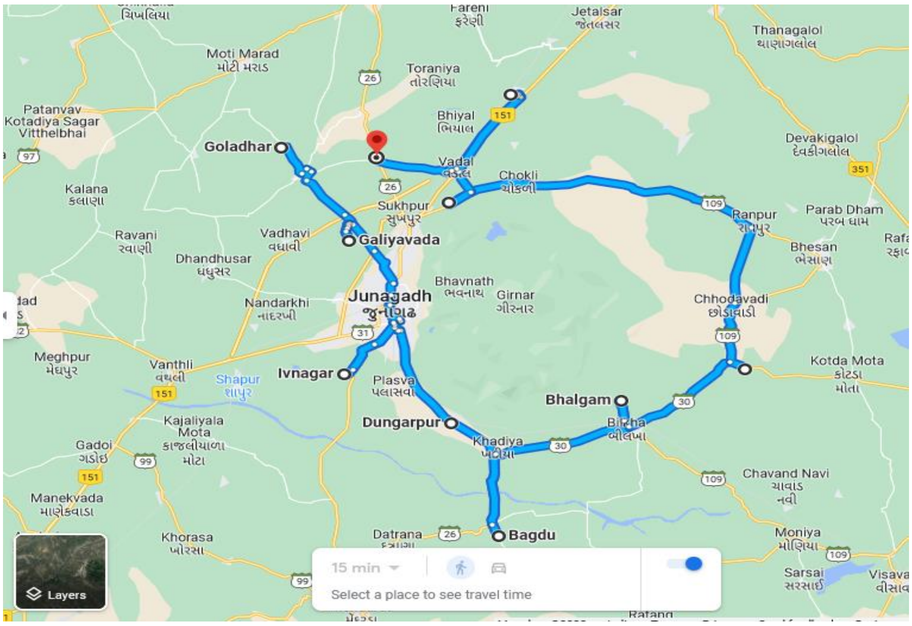

Figure 1: Study area location map (source: Google)

3.2 Measurement of infiltration

In the present research region, a double-ring infiltrometer was used to perform the infiltration test at 24 locations [Das, Kumar, et al., (2023); Shamohammadi, Kadkhodahosseini, et al., (2023)].The field test was conducted during the period January 2023 to May 2023. The longitude, latitude, and altitude of each infiltrometer station were measured through the Global Positioning System. According to Figure 2, there are two concentric rings in this: the inside and outside, with diameters of 30 and 60 cm, respectively, and a depth of 25 cm. By using a falling weight-style hammer to strike a wooden plank that is placed on top of the ring without disturbing the soil, the two rings are driven deep down into the earth of around 15 cm. A constant depth of around 5 to 12 cm is maintained by adding water to both rings. The outer ring acts as a water jacket to stop water infiltrating from the inside ring. For the duration of the observation, the water depths in the inside and outside rings remain unchanged. Only the inside ring is used to measure the water volume. The experiment is run repeatedly until the infiltration rate becomes constant. Early in the examination, the readings were taken regularly; but, as time went on, the distance between readings became longer. The basic infiltration rate has been attained when the infiltration rate values are steady. Figure 2 below clearly depicts the double-ring infiltrometer and infiltration tests at various locations in JunagadhTaluka.

Figure 2: Double-ring infiltrometer and infiltrometer testsat various locations in JunagadhTaluka.

4. Results and discussion

The IR of soil in the field was evaluated using a double-ring infiltrometer across 24 different blocks within Junagadh Taluka. The presence of air within the soil influences the downward flow of water during infiltration, with the complete removal of air being impractical without compaction. Consequently, air presence acts as a controlling factor in infiltration dynamics. The outcomes of the infiltration rate measurements at the twenty-four different blocks, as recorded in Table 2 to Table 6, provide valuable insights into the spatial variability of infiltration characteristics. These measurements were conducted under varying environmental conditions, including wind speed and temperature, which play crucial roles in soil moisture dynamics and infiltration rates. High wind speeds can accelerate evaporation from the soil surface, potentially impacting the accuracy of infiltration measurements, while temperature influences soil moisture content and evaporation rates, thereby affecting infiltration dynamics. Furthermore, the inclusion of map coordinates allows for the spatial distribution of infiltration rates to be analyzed across different blocks or study areas. This spatial information is instrumental in identifying patterns in infiltration rates and investigating factors contributing to spatial variability, such as topography, land use, and soil type [Jobbágy, Krištof, et al., (2023)]. It was observed that initial infiltration rates were higher and gradually decreased over time, eventually reaching a steady state across all sites tested. This phenomenon underscores the influence of compaction, vegetation cover, hydraulic conductivity, soil texture, and soil structure on infiltration dynamics. The precise measurements of water level changes over time during infiltration tests, coupled with the recording of environmental variables and map coordinates, provide a comprehensive understanding of the factors influencing infiltration processes within the study area. The below figure 3 likely depicts a graph presenting the infiltration rates of the 24 blocks, ranked from highest to lowest.

Table 2: The outcomes of the infiltration rate measurements from block 1 to block 5.

Block: 1	Location: Khadiya	Date: 29/1/23, time:08:30 am	Wind speed:11Kmh	Map coordinate: 21.5871° N, 70.2565° E	Temperature: 29^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.6	13.5	1.1	64.7	1.1

11	15	13.8	1.4	41.17	8.9
40	15	12.3	0.2	2.38	20.2
50		11.9	0.2	2.38	20.6
Block: 2	location: Toraniya	Date: 29/1/23, time: 02:30 am	Wind speed: 12Kmh	Map coordinate: 21.4382° N, 70.5455° E	Temperature: 30^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.2	14.3	0.9	52.94	0.9
11	15	14.7	0.3	9.09	6
50	15	14.9	0.1	2.38	8.8
65		14.6	0.1	1.2	9.1
Block: 3	location: Ivnagar	Date: 11/2/23, time:10:15 am	Wind speed 10.5Kmh	Map coordinate: 21.5025°N 70.4182°E	Temperature: 29.5^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	16.5	16	0.5	29.41	0.5
11	16.5	16.1	0.4	12.12	2.9
30	16.4	16.2	0.2	2.41	4.3
45		15.6	0.2	2.41	4.9
Block: 4	location: palasva	Date:11/2/23, time: 04:30 pm	Wind speed: 11.6Kmh	Map coordinate: 21.50245°N 70.41795°E	Temperature: 31^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.3	14.4	0.9	52.94	0.9
7	15	15.1	0.4	12.12	4.1
30	15	14.5	0.5	6.02	7
60		12.6	0.3	3.61	8.9

Block: 5	location: Galiyavada	Date- 12/2/23, time:09:00 am	Wind speed 13Kmh	Map coordinate: 21.3349°N 70.2633°E	Temperature: 32^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	InfiltrationRate (cm/h)	Accumulated infiltration (cm)
1	15	13.7	1.3	76.47	1.3
7	15.2	14.1	0.4	12.12	4.5
15	15.1	14.4	0.3	9.09	6.1
50		12.4	0.3	3.61	8.7

Table3: The outcomes of the infiltration rate measurements from block 6 to block 10.

Block: 6	location: valasimdi	Date: 29/1/23, time:11:55 am	Wind speed: 12Kmh	Map coordinate: 21.6309° N, 70.4224° E	Temperature: 34^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14	12.8	1.2	70.59	1.2
20	14.2	13.2	0.4	4.82	8.5
40	14	13.6	0.3	3.61	10.1
65		12.5	0.2	2.41	11.4
Block: 7	location: Majevdi	Date: 17/2/23, time: 04:10 pm	Wind speed: 11.5Kmh	Map coordinate: 21.6069° N, 70.4067° E	Temperature: 33^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.5	12.8	1.7	100	1.7
15	14.4	13.5	0.9	27.27	10.2
40	14.5	14	0.5	6.02	12.9
65		12.5	0.1	1.20	14.4
Block: 8	location: Goladhar	Date:18/2/23, time: 01:10 pm	Wind speed: 12Kmh	Map coordinate: 21.6248° N, 70.3956° E	Temperature: 32^{0}c
Time (Min	Commencement water volume	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltratio

)	(cm)				n (cm)
1	15	13.9	1.1	64.71	1.1
7	15.2	14.1	1.1	33.33	6.5
15	15.1	14.4	0.9	27.27	10.8
40		13	0.2	2.41	12.2
Block: 9	location: Patrapsar	Date:18/2/23, time: 04.30 pm	Wind speed: 13Kmh	Map coordinate: 21.5793° N, 70.3780° E	Temperature: 32^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.8	13.3	1.5	88.24	1.5
20	15	14.3	0.7	8.43	10
40	14.8	14.4	0.4	4.82	12.2
45		14	0.4	4.82	12.6
Block:10	location: Dungurpur	Date: 26/2/23, time: 11:20 am	Wind speed: 12Kmh	Map coordinate: 21.4454° N, 70.4938° E	Temperature: 33^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	13.5	13	0.5	29.41	0.5
7	14.5	13.7	0.8	24.24	3.9
15	14.2	13.8	0.3	9.09	5.8
50		12.5	0.1	1.20	7

Table 4: The outcomes of the infiltration rate measurements from block 11 to block 15.

Block: 11	location: Padariya	Date: 26/2/23, time: 4:10 pm	Wind speed: 12Kmh	Map coordinate: 21.4665° N, 70.4737° E	Temperature: 32^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	13.8	12.4	1.4	82.35	1.4
7	14	13.3	0.7	21.21	5.7
15	14.2	13.8	0.6	18.18	8
35		12.2	0.4	4.82	9.6
Bloc	location:	Date: 5/3/23,	Wind speed:	Map coordinate:	Temperat

k: 12	Khalilpur	time: 1:05 pm	11Kmh	21.4665° N, 70.4737° E	ure: 33^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	13.5	11.8	1.7	100	1.7
15	14.1	13.2	0.9	27.27	10.6
55	13.9	13.5	0.4	4.82	17.2
70		12.3	0.3	3.61	18.2
Block: 13	location: Vadhavi	Date: 5/3/23 , time: 04:50	Wind speed: 11.5Kmh	Map coordinate: 21.5639° N, 70.3977° E	Temperature: 32^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.5	12.4	2.1	123.53	2.1
15	14.2	13.7	0.5	15.15	8.6
40	14.3	13.9	0.4	4.82	11.6
65		12.3	0.3	3.61	13.2
Block: 14	location: Makhiyala	Date: 19/3/23, time:1:05 pm	Wind speed: 13.5Kmh	Map coordinate: 21.6186° N, 70.4506° E	Temperature: 30^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.8	12.9	1.9	111.76	1.9
15	14.3	13.2	0.9	27.27	13.4
40	14	13.2	0.8	9.64	17.7
65		9.8	0.6	7.23	21.1
Block: 15	location: Sukhpur	Date: 19/3/23, time: 4:30 pm	Wind speed: 11.5Kmh	Map coordinate: 21.5821° N, 70.4663° E	Temperature: 30^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	13.9	11.5	2.4	141.18	2.4
40	14.1	13.2	0.9	10.84	18.4
70	14.2	13.7	0.5	6.02	22.7
100		9.5	0.5	6.02	26.3

Table5: The outcomes of the infiltration rate measurements from block 16 to block 24.

Block: 16	location: Bilkha	Date: 1/4/23, time: 03:50 pm	Wind speed: 12Kmh	Map coordinate: 21.4404° N, 70.5949° E	Temperature: 31^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.5	12.8	1.7	100	1.7
15	14.4	13.5	0.9	27.27	10.2
40	14.5	14	0.5	6.02	12.9
60		12.6	0.1	1.20	14.3
Block: 17	location: Bagdu	Date: 2/4/23, time: 01:45 pm	Wind speed: 11.5Kmh	Map coordinate: 21.3715° N, 70.5205° E	Temperature: 31^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.2	13.7	1.5	88.24	1.5
15	15.3	14.1	1.4	42.42	12.6
40	14.9	13.8	1.1	13.25	17.7
65		9.7	0.6	7.23	21.8
Block: 18	location: Bhalgam	Date: 2/4/23, time: 4:55 pm	Wind speed: 11.5Kmh	Map coordinate: 21.4600° N, 70.5919° E	Temperature: 30.5^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15.2	13.3	1.9	111.76	1.9
20	15.1	14.2	0.8	9.64	14.5
40	14.9	14.1	0.8	9.64	18.6
55		12	0.7	8.43	20.7
Block: 19	location : Nava Pipliya	Date:16/4/23, time: 01:25 pm	Wind speed: 10.5Kmh	Map coordinate: 21.44575°N 70.61445°E	Temperature: 32^{0}c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration

					(cm)
1	13.8	12.9	1.1	64.71	1.1
15	14.4	13.7	0.7	21.21	7.4
45	14.2	13.8	0.4	4.82	10.7
55		13	0.4	4.82	11.5
Block: 20	location: Madlikpur	Date: 16/4/23, time: 04:50 pm	Wind speed: 11.5Kmh	Map coordinate: 21.3493° N, 70.5317° E	Temperature: 32^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	13.8	12.4	1.4	82.35	1.4
7	14	13.3	0.7	21.21	5.7
15	14.2	13.8	0.6	18.18	8
30		12.6	0.4	4.82	9.2

Table 6: The outcomes of the infiltration rate measurements from block 21 to block 24.

Block: 21	location: Bamangam	Date: 7/5/23, time: 01:10 pm	Wind speed: 12Kmh	Map coordinate: 21.5890° N, 70.4919° E	Temperature: 33^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	15	13.2	1.8	105.88	1.8
7	15.2	13.9	1.3	39.39	7.8
15	14.8	14	0.8	24.24	11.6
40		10.6	0.7	8.43	15
Block: 22	location: Bhavnath	Date: 7/5/23, time: 05:10 pm	Wind speed: 13.5Kmh	Map coordinate: 21.5334° N, 70.5012° E	Temperature: 32^0c
Time (Min)	Commencement water volume (cm)	Termination water volume (cm)	Decrementing water volume (cm)	Infiltration Rate (cm/h)	Accumulated infiltration (cm)
1	14.3	11.9	2.4	141.18	2.4
15	14.4	13.8	0.6	18.18	13.2
45	14	13.5	0.5	6.02	17.3
55		12.7	0.4	4.82	18.1
Bloc	location:	Date: 28/5/23,	Wind speed:	Map coordinate:	Temperat

k: 23	Vadal	time: 09:30 am	12.5Kmh	21.6113° N, 70.4970° E	ure: 34^{0}c
Time (Min)	Commence ment water volume (cm)	Termination water volume (cm)	Decrementin g water volume (cm)	Infiltration Rate (cm/h)	Accumula ted infiltratio n (cm)
1	13.8	12.4	1.4	82.35	1.4
15	14.2	13.8	0.6	18.18	7.7
45	14.1	13.7	0.4	4.82	11.1
65		11.7	0.5	6.02	13.1
Bloc k: 24	location: Choki	Date: 28/5/23, time: 12:15 pm	Wind speed: 12Kmh	Map coordinate: 21.6619° N, 70.5302° E	Temperat ure: 34^{0}c
Time (Min)	Commence ment water volume (cm)	Termination water volume (cm)	Decrementin g water volume (cm)	Infiltration Rate (cm/h)	Accumula ted infiltratio n (cm)
1	14.9	12.8	2.1	123.53	2.1
15	14.3	13.4	0.9	27.27	13
40	14.5	14	0.4	4.82	16.1
55		13.1	0.3	3.61	17

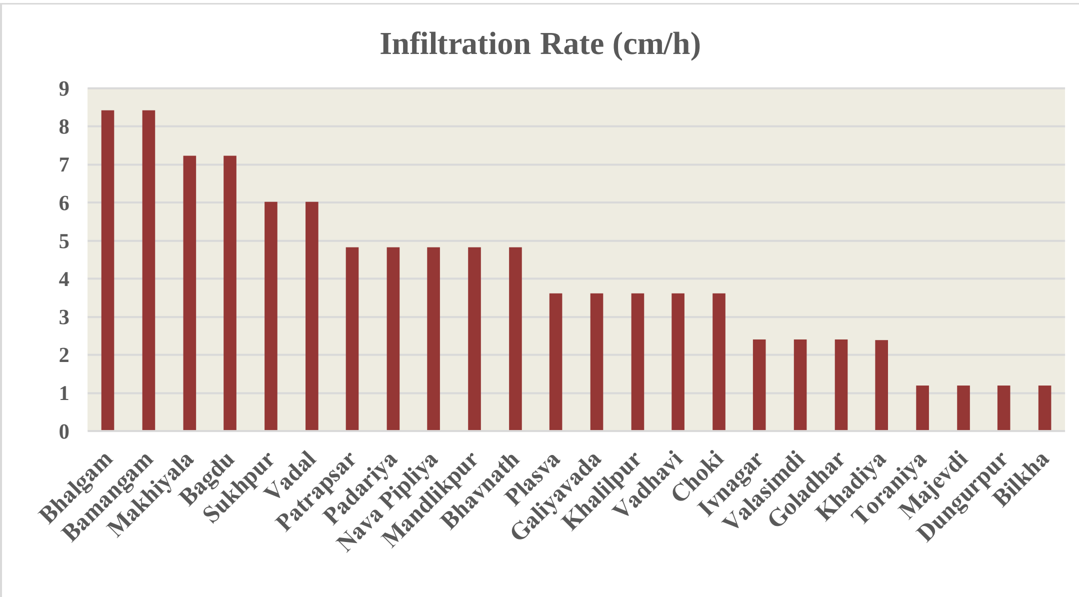

Figure 3: Infiltration rate of the 24 block from highest to lowest.

Table7: The conclusive infiltration rate observed across the 24 blocks in Junagadh Taluka

Sr.no	Village (block)	Infiltration Rate (cm/h)	Sr.no	Village (block)	Infiltration Rate (cm/h)
1	Khadiya	2.38	13	Vadhavi	3.61
2	Toraniya	1.2	14	Makhiyala	7.23
3	Ivnagar	2.41	15	Sukhpur	6.02
4	Plasva	3.61	16	Bilkha	1.20
5	Galiyavada	3.61	17	Bagdu	7.23
6	Valasimdi	2.41	18	Bhalgam	8.43
7	Majevdi	1.20	19	Nava Pipliya	4.82
8	Goladhar	2.41	20	Mandlikpur	4.82
9	Patrapsar	4.82	21	Bamangam	8.43
10	Dungurpur	1.20	22	Bhavnath	4.82
11	Padariya	4.82	23	Vadal	6.02
12	Khalilpur	3.61	24	Choki	3.61

The experiment conducted on soil infiltration rates across various villages revealed significant disparities. Higher rates were observed in villages like Bhalgam, Bamangam, Makhiyala, Bagdu, Sukupur, and Vadal, indicating more permeable soils, while moderate rates were found in villages such as Patrapasar, Padariya, Nava Pipaliya, Mandlikpur, Bhavnath, Plasva, Galiyavada, Khalilpur, Vadhavi, and Choki. Conversely, villages like Ivnagar, Valasimdi, Goladhar, Khadiya, Torniya, Majevdi, Dungurpur, and Bilkha exhibited the lowest infiltration rates, indicative of compacted soils. The infiltration rate was notably highest in Bhalgam and Bamangam, reaching 8.43, surpassing all other locations. Table7 lists the final infiltration rate of 24 blocks in Junagadhtaluka. Reductions in organic content and vegetation were identified as factors contributing to decreased evapotranspiration losses and increased runoff. These findings underscore the importance of understanding infiltration rates for effective water management and environmental planning, with implications for mitigating issues like soil erosion and flooding. Areas with higher infiltration rates demonstrate better water absorption capabilities, potentially reducing surface runoff and contributing to sustainable water balance within the region.

The principal findings will also function as a roadmap for well-informed practice decision-making, especially in areas with insufficient data. By ensuring better planning and management of the region's recurrent flood and drought issues, they might also be useful in comprehending the local hydrological processes. To preserve water, more care must be taken in the blocks with poor infiltration rates. To create a generalized hydrological model, more research is necessary to comprehend the mechanism of runoff creation under various soil surface conditions and to take into account the geographical variability of infiltration in conjunction with runoff formation.

5. Conclusion

Environmental preservation and water resource management both heavily depend on the study of soil infiltration properties. Measurement of infiltration in the field will play a significant role in forecasting runoff from land uses following precipitation and in determining ways to save water and soil. Gaining a thorough grasp of the site-specific and intricate spatial water infiltration characteristics over soil due to its non-uniformity could help improve agricultural water usage efficiency and alleviate water-related problems. Therefore, employing a double-ring infiltrometer, this study investigates the field observation of infiltration characteristics across all 24 blocks of the Junagadh taluka in Gujarat, encompassing a diverse array of soil types. The research demonstrated that the soil IR highest at bhalgam, bamangam, makhiyala, bagdu, sukupur, vadal and Moderate at patrapasar, padariya, navapipaliya, mandlikpur, bhavnath, plasva, galiyavada, khalilpur, vadhavi, choki and Lowest at ivnagar, valasimdi, goladhar, khadiya, torniya, majevdi, dungurpur, bilkha. The highest infiltration rate was observed in Bhalgam and Bamangam, reaching 8.43, which is the highest among all locations. The villages or blocks with higher infiltration rates of 4.82 cm/h and above are considered to have more permeable or easily penetrable soils, while those with lower rates of 1.2 cm/h have less permeable or compacted soils. Upon comparing these rates, it is evident that certain areas exhibit faster water penetration than others. Higher infiltration rates are often beneficial as they assist in recharging groundwater and mitigating surface runoff. According to the current investigation, various soil conditions have an impact on the infiltration rate. It offers further insight into the variety of the local soil infiltration. The test's results were discovered to differ depending on the type of soil and soil condition. The study concludes that, in comparison to compacted and unploughed soil, the infiltration rate of ploughed soil is higher. The experimental study conducted in the Junagadh Taluka of Gujarat, India, has provided valuable information on infiltration patterns and spatial variability of soil properties. The findings contribute to the understanding of local soil behavior and can inform decision-making processes related to land management and engineering practices in the region.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability statement

All the data is collected from the simulation reports of the software and tools used by the authors. Authors are working on implementing the same using real world data with appropriate permissions.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Ethical approval and human participation

No ethics approval is required.

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