iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.78566

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

Grain Size Distribution Analysis of Italva Village Soil and its Influence on Groundwater Quality in Navsari District, Gujarat

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Abstract: ***Groundwater is the primary source of drinking and irrigation water in many rural regions of Gujarat. The quality and recharge potential of groundwater are significantly influenced by the physical properties of soil, particularly grain size distribution. Grain size characteristics determine soil permeability, filtration capacity, and hydraulic conductivity, which collectively affect groundwater movement and natural purification processes. The present study investigates the grain size distribution of soil samples collected from Italva village in Navsari district, Gujarat, to understand their influence on groundwater recharge and quality. Laboratory sieve analysis was performed to determine particle size distribution and soil gradation characteristics. Parameters such as effective particle size (D10), coefficient of uniformity (Cu), and coefficient of curvature (Cc) were calculated. The results indicate that the soil predominantly consists of fine to medium sand with minor silt fractions, suggesting moderate permeability and favorable groundwater recharge conditions. The grain size distribution curve also indicates that the soil possesses natural filtration properties that can contribute to groundwater quality improvement. The findings of this study are useful for planning groundwater management strategies and designing artificial recharge structures in Italva village.***

Keywords: Grain size analysis, groundwater quality, soil permeability, sieve analysis.

I. INTRODUCTION

Groundwater resources play a crucial role in sustaining rural communities, agriculture, and ecosystems. In India, particularly in the state of Gujarat, groundwater accounts for a significant proportion of water supply used for drinking and irrigation. However, increasing groundwater extraction, population growth, and agricultural activities have created challenges related to groundwater sustainability and quality [1]. The movement and storage of groundwater largely depend on the physical properties of soil and geological formations. Among these properties, grain size distribution is one of the most important parameters influencing soil permeability and infiltration characteristics [2]. Grain size analysis helps determine the proportion of different soil particles such as gravel, sand, silt, and clay. Coarse-grained soils generally allow rapid infiltration of water, whereas fine-grained soils restrict water movement [3]. As a result, grain size distribution plays an important role in: groundwater recharge, natural filtration of contaminants, aquifer permeability, groundwater flow characteristics. The study area, Italva village in Navsari district, is located in the southern region of Gujarat where groundwater is widely used for irrigation and domestic purposes. Understanding soil characteristics in this region is essential for sustainable groundwater management [4]

Therefore, the objective of this research is to analyse the grain size distribution of Italva village soil and evaluate its implications for groundwater recharge and groundwater quality.

II. LITERATURE REVIEW

Grain size analysis has long been recognized as a fundamental method for understanding soil behaviour and hydrogeological properties.

Terzaghi and Peck (1967) explained that soil permeability is strongly influenced by particle size distribution and soil structure. Coarse soils such as sand and gravel generally exhibit higher hydraulic conductivity compared to fine-grained soils.

According to Das (2015), grain size distribution curves help classify soils and determine engineering properties such as permeability, compressibility, and shear strength.

Freeze and Cherry (1979) emphasized that groundwater flow through aquifers is significantly controlled by soil texture and grain size distribution.

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Fetter (2001) stated that sandy soils allow greater groundwater recharge and faster water movement, whereas clay soils act as barriers to groundwater flow.
Research conducted by Kumar et al. (2018) in Gujarat found that areas with sandy alluvial soils exhibit better groundwater recharge potential.
Similarly, the Central Ground Water Board (CGWB) reports that soil permeability and aquifer characteristics are key factors determining groundwater availability and quality in India.
These studies highlight the importance of grain size analysis for evaluating soil permeability and groundwater recharge potential.

III. STUDY AREA

The study area, Italva village, is located in Navsari district in the southern part of Gujarat, India.

Table 1: Geographic Characteristics

Parameter	Description
District	Navsari
State	Gujarat
Climate	Tropical monsoon
Average rainfall	Approx 1500 mm/year
Main Occupation	Agriculture

The geology of the region mainly consists of alluvial soil deposits containing sand, silt, and clay layers. These sediments influence groundwater infiltration and storage capacity.

IV. METHODOLOGY

To achieve a comprehensive profile of the Italva site, the following experimental procedure was adopted:

A. Sample Collection

Soil samples were collected from three different locations within Italva at depths ranging from 2.0 to 5.0 meters to represent the primary saturated zone.

B. Sieve Analysis

A standard mechanical sieve analysis was performed. Equipment Used are Standard sieve set, Mechanical sieve shaker, Oven, Weighing balance, Sample trays.

Table 2 Grainsize Distribution Analysis

Grain Size Distribution analysis				
Sieve Size	weight retained (gms)	% retained	cumulative %retained	cumulative % passing
4.75	306	30.6	30.6	69.4
2.36	289	28.9	59.5	40.5
1.18	218	21.8	81.3	18.7
0.6	121	12.1	93.4	6.6
0.3	53	5.3	98.7	1.3
0.15	8	0.8	99.5	0.5
0.075	4	0.4	99.9	0.1
PAN	0	0	100	0

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The procedure adopted for grain size analysis was as follows:

1) Soil samples were oven dried to remove moisture.
2) The dried sample was weighed.
3) The sample was passed through a series of standard sieves.
4) The weight of soil retained on each sieve was recorded. (Table 2)
5) The percentage retained and cumulative percentage passing were calculated. (Table 2)
6) A grain size distribution curve was plotted(Figure 1).

C. Data Processing

The grain size distribution curve (semi-logarithmic plot) was generated to calculate:

1) Uniformity Coefficient: Cu = (D60) / (D10)
2) Coefficient of Curvature: Cc = $(D30)^2$ / (D60 x D10)

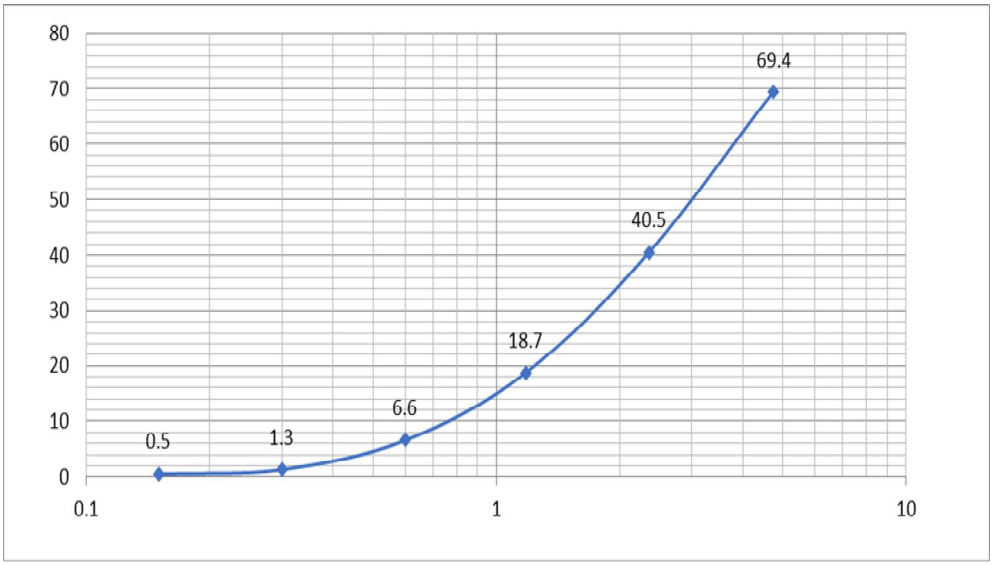


Figure 1 : Grain Size Distribution Curve

V. RESULTS AND DISCUSSION

A. Soil Classification and Hydraulic Conductivity Analysis

From the grain size distribution data D10, D30 and D60 computed and Based on these values Co-efficient of Uniformity and Co-efficient of Curvature is Computed as follows:

- D10 = 0.73 mm
- D30 = 1.69 mm
- D60 = 3.78 mm

B. Coefficient of Uniformity (Cu):

Cu = (D60) / (D10)
= 3.78/0.73 = 5.18

C. Coefficient of Curvature (Cc):

Cc = $(D30)^2$ / (D60 x D10)
= $(1.69)^2$ / (3.78 x 0.73) = 1.04

Table 3: Hydraulic Conductivity determination for Soil sample of Italva, Navsari

Determination of Hydraulic conductivity(K) from Grain size Distribution						
HAZEN'S METHOD: K= C* D10*D10						
RESULTS (mm)		Cc	Cu	K (m/s)	K (cm/s)	K (ft/d)
D10	0.73	1.04	5.18	0.00533	0.533	1510
D30	1.69					
D60	3.78					

D. Soil Classification (USCS)

For sandy soils:

Table 4: Classification of soil

Condition	Requirement
Well graded sand (SW)	$Cu \geq 6$ and $1 \leq Cc \leq 3$
Poorly graded sand (SP)	$Cu < 6$

Since, Cu = 5.18 (< 6) and Cc = 1.04 (between 1 and 3), The soil is classified as Poorly Graded Sand (SP).

E. Hydraulic Conductivity (Hazen's Method)

Using Hazen's formula:

$$K = C \times (D10)^2$$

Where, $C \approx 100$ for clean sand.

Calculated values of K based above data and formula,

$$K = 0.00533 \text{ m/s}$$

or $K \approx 1510$ ft/day

Hydraulic Conductivity of Study area Italva, Navsari is determine using Hazen's formula is 0.00533 m/s (1510 ft/day) indicate the Italva study area as a highly permeable zone suggests high aquifer productivity suitable for groundwater recharging in the study area.

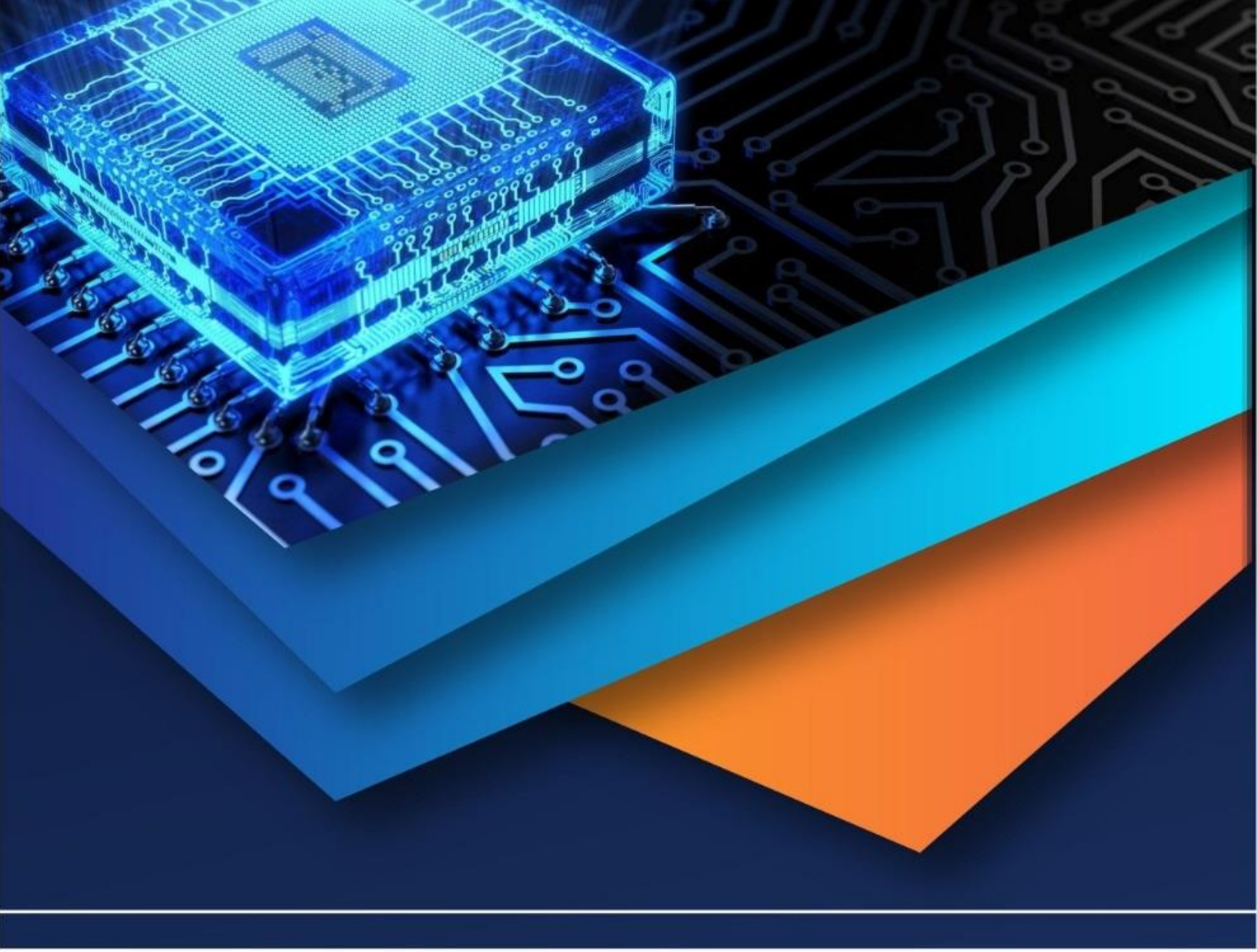
VI. CONCLUSION

The present study evaluated the grain size distribution of soil samples from Italva village in Navsari district, Gujarat to understand their influence on groundwater recharge and quality. The results of sieve analysis indicates that the soil is classified as Poorly Graded Sand (SP) with high hydraulic conductivity, making it favourable for groundwater recharge in the Italva area of Navsari district. As the hydraulic conductivity value indicates high permeability, such type of sandy soils allow water to infiltrate easily through soil pores, which promotes groundwater recharge. Therefore, the soil in the study area supports groundwater recharge and contributes to maintaining groundwater quality, which is suitable for groundwater recharge structures such as Recharge wells, Percolation pits, Infiltration basins. Regular monitoring of soil and groundwater characteristics is essential for ensuring long-term sustainability of groundwater resources in Italva village.

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