ENVIRONMENTAL QUALITY ASSESSMENT OF GROUNDWATER USING GIS TECHNIQUES IN THE WAGHOLI VILLAGE REGION

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ABSTRACT

This study has evaluated and mapped the groundwater quality in the Wagholi Village region by using GIS in combination with laboratory tests. The research area's acceptable criteria for pH, alkalinity, calcium, and magnesium are typically satisfied by these water quality metrics, according to the regional distribution maps of these parameters. Nonetheless, the analysis of Electrical Conductivity (EC) values indicates that more than 90% of the groundwater within the research region is unfit for human consumption. Furthermore, the distribution map of alkalinity concentrations reveals that, with the exception of samples at sampling sites 6, the majority of samples do not reach allowable levels. Although samples from points 1, 2, 4, and 10 surpass allowable limits, overall calcium ion levels are within acceptable bounds. At every area, the amounts of magnesium ions are typically within acceptable bounds. With the exception of the regions around sampling sites 1, 2, 5, 8, and 10, the bulk of the study area has a Water Quality Index (WQI) value of less than 50, according to the overall evaluation. Notwithstanding these conclusions, groundwater is still fit for household use and drinking in the majority of the research area, with the exception of Shree Datta Pharma, President English Medium School, Sai Sanskruti Apartment, Wagheshwar Temple, and Mauli Balak Ashram. This study emphasizes how valuable GIS and remote sensing are as essential resources for thoroughly evaluating groundwater quality. For the purpose of making well-informed decisions and managing groundwater resources sustainably in the Wagholi Village region, a nuanced knowledge of the distribution and significance of numerous water quality criteria has been made possible by the thorough spatial analysis made possible by GIS.

Keywords- Groundwater Quality, GIS, Spatial Distribution, Electrical Conductivity, Water Quality Index (WQI), pH, Alkalinity, Calcium, Magnesium.

I. INTRODUCTION

One of the most severely damaged natural resources in emerging regions is groundwater due to the growing urbanization and industrialization of these areas[1]. In rural locations where surface water supply is limited or polluted, groundwater plays a vital role as a source of drinking water. However, human activities like agriculture, the release of industrial waste, and uncontrolled land use have resulted in the degradation of groundwater quality, as has the unrestrained use of its resources[2]. This also applies to the Maharashtra, India village of Wagholi, which is close to Pune. Wagholi has seen tremendous urbanization and population increase in recent years, which may have a negative impact on the environment, especially with regard to groundwater quality. Therefore, in order to guarantee the wellbeing and sustainability of the region's water resources, an environmental quality evaluation of the groundwater in the Wagholi area becomes crucial[3]. In areas where surface water is scarce or difficult to get, groundwater is frequently considered a dependable supply of fresh water. In places like Wagholi, where agriculture and small-scale enterprises are common, groundwater plays a significant role in satisfying the water demands of families, agricultural activities, and industry. Unfortunately, the quality of the water has been harmed by the widespread extraction of groundwater and the careless release of contaminants[4]. Determining the level of groundwater contamination is crucial since it can cause serious health problems for the people who rely on it.

Geographic Information Systems (GIS) have become one of the most effective instruments for monitoring and evaluating the environment[5]. By combining several data sources, including hydrogeological data, land use patterns, and water quality metrics, GIS tools allow researchers to evaluate spatial patterns of groundwater quality[6]. The application of GIS in environmental research has offered a complete platform for monitoring the distribution of contaminants, detecting contamination hotspots, and understanding the mechanisms contributing to groundwater deterioration[7]. Researchers may more easily adopt techniques for sustainable water management by using

GIS technology to construct spatial models that offer a more comprehensive perspective of groundwater quality concerns. Once mostly an agricultural zone, the Wagholi region has become a semi-urban area because of Pune's close vicinity and the increasing demand for industrial and residential facilities[8]. Alongside this expansion have come more practices that endanger the quality of groundwater, such as the inappropriate disposal of industrial effluents, the use of chemical fertilizers, and the lack of suitable sewage treatment facilities. These elements raise the possibility of contaminants like nitrates, heavy metals, and other dangerous materials into groundwater[9]. Since groundwater serves as Wagholi people' main supply of water, it is important to evaluate the environmental quality of the area to determine the level of pollution and any potential effects it may have on agricultural production and public health.

FIG.1 Ground Water Analysis

The primary objective of this study is to evaluate the environmental quality of groundwater in the Wagholi village region by using GIS techniques[10]. The research will focus on identifying the spatial distribution of groundwater pollutants, analyzing the factors contributing to contamination, and proposing solutions for groundwater quality management[11]. By understanding the current status of groundwater in Wagholi, this study aims to assist local authorities and stakeholders in making informed decisions regarding groundwater use and protection[12]. In conclusion, the environmental quality assessment of groundwater in Wagholi using GIS techniques is an essential step in safeguarding the health and well-being of its residents. This research will contribute to the broader understanding of groundwater contamination in rapidly developing semi-urban areas and offer a model for future studies in similar regions.

1.1 A Focus on Water Pollution

Particularly in semi-urban and rural settings where surface water supplies are frequently limited, groundwater is an essential resource[13]. The Wagholi Village area, which is outside of Pune, India, has seen a sharp increase in both urbanization and agricultural growth recently. The surrounding ecology has been greatly harmed by this development, especially the groundwater quality[14]. In order to protect inhabitants' health and safety who depend on groundwater for drinking, irrigation, and other everyday needs, it is imperative to evaluate the environmental quality of the resource. Groundwater contamination may be effectively and precisely assessed, and its geographical distribution can be mapped, using Geographic Information System (GIS) approaches. This study employs GIS tools to evaluate the environmental quality of groundwater in the Wagholi Village region, with an emphasis on water pollution[15].

Two main causes of the groundwater contamination in Wagholi Village are the discharge of urban wastewater and agricultural runoff[16]. The usage of pesticides and fertilizers has increased in tandem with the village's increased agricultural activity. Pollution results from these chemicals when they are not adequately handled since they ultimately leak into the soil and groundwater supplies[17]. Overuse of fertilizers resulting in nitrate pollution is a prevalent problem in farming areas such as Wagholi. Wastewater is being improperly disposed of in the hamlet due to expanding population and poor sewage facilities, in addition to agricultural runoff[18]. The growth of metropolitan areas results in the discharge of industrial and household wastewater onto adjacent land, which causes organic contaminants, nitrates, and heavy metals to seep into groundwater[19]. The region's groundwater's environmental quality is seriously threatened by the mix of urban and agricultural sources.

The spatial distribution of groundwater contamination has been analyzed using GIS techniques, which have been demonstrated to be invaluable instruments[20]. GIS was employed in this investigation to map the quality of groundwater in Wagholi Village. This was achieved by analyzing critical parameters, including pH levels, nitrates, total dissolved solids (TDS), and the presence of heavy metals like lead and arsenic[21]. Data were gathered from a variety of borewells and manual pumps in the area and incorporated into a GIS database. The analysis identified regions with elevated levels of contamination, particularly those that were situated in close proximity to urbanized areas and agricultural fields[22]. The spatial mapping of these contaminants is essential for the effective management of groundwater, as it enables a visual comprehension of contamination regions[23]. Furthermore, GIS techniques aid in the identification of the underlying patterns of contamination, thereby enabling local authorities and stakeholders to make well-informed decisions regarding pollution mitigation and water resource management[24].

1.2 Role of GIS in Groundwater Quality Assessment

In the Wagholi Village region, the Geographic Information System (GIS) is an essential instrument for evaluating the condition of groundwater[25]. The region, which is distinguished by its rapid urbanization and agricultural activities, is at risk of groundwater contamination from sources such as untreated effluent, fertilizers, and industrial discharges. The environmental condition of groundwater is evaluated by integrating spatial data from a variety of sources, such as hydrogeological studies, land use maps, and well data, using GIS techniques[26]. For instance, GIS can overlap data layers that indicate the proximity of potential contaminants (e.g., industrial zones, agriculture, and waste disposal sites) with groundwater sampling locations[23]. This assists in the identification of high-risk areas where groundwater contamination is more likely, thereby enabling a more targeted monitoring approach. By employing spatial interpolation techniques such as Inverse Distance Weighting (IDW) or Kriging, GIS can map the distribution of contaminants by utilizing groundwater quality parameters, including pH, nitrate, chloride, and heavy metal concentrations, which are collected from well samples[27]. In Wagholi, spatial analysis using GIS identified regions where nitrate levels exceeded the permissible limits, primarily as a result of agricultural runoff[28]. Environmental agencies are able to develop mitigation strategies, such as the regulation of agricultural inputs or the enhancement of effluent management, by utilizing this data for visualization. Additionally, the integration of GIS facilitates temporal analysis to evaluate fluctuations in water quality over time[29].

In addition to its function in evaluating the current purity of water, GIS is essential for the predictive modeling of the groundwater in the Wagholi Village region. GIS-based models can forecast future water quality trends under various scenarios by relating historical water quality data, rainfall patterns, and land use changes[30]. For example, GIS models may anticipate an increase in contaminants in groundwater, including nitrates and phosphates, if urbanization persists in Wagholi without intervention. Spatial decision support systems (SDSS) and other GIS-enabled tools enable policymakers and environmental managers to simulate a variety of land use and conservation strategies in order to identify those that are effective[31]. By visualizing the potential impacts of environmental or regulatory changes, this proactive approach guarantees the sustainable management of groundwater resources. Furthermore, GIS-based models assist in the establishment of water quality zones, suggesting the establishment of protected zones or low-development regions to preserve groundwater quality[32]. Consequently, GIS not only offers a current assessment of the status of groundwater but also functions as a decision-making instrument to anticipate and alleviate future water quality concerns in the Wagholi Village region.

1.3 Significance of Groundwater Analysis

It is imperative to conduct groundwater analysis in Wagholi Village using a Geographic Information System (GIS) to evaluate environmental quality and guarantee sustainable water management[33]. Groundwater is a critical resource for agriculture, industry, and consumption, necessitating consistent quality monitoring[34]. GIS is a potent instrument for the analysis of water quality trends, the mapping of spatial data, and the identification of contamination sources. Total dissolved solids (TDS), chloride, fluoride, and nitrate concentrations, as well as pH levels, have been assessed in the Wagholi region[35]. Contamination may be indicative of factors such as industrial effluent or improper waste disposal when these elements are present in high concentrations. For example, elevated nitrate levels may indicate agricultural pollution from fertilizers, while high chloride and fluoride concentrations may indicate industrial effluents or geogenic sources[31]. A comprehensive mapping of these factors enables the identification of areas where water quality is compromised, thereby assisting authorities in the implementation of targeted remediation strategies[36]. GIS-based groundwater analysis is especially important in regions such as Wagholi, where the purity of water is at risk due to accelerated urbanization and industrialization. The formulation of sustainable water management strategies that mitigate overexploitation and pollution is facilitated by an understanding of groundwater dynamics, which includes flow patterns and recharge areas[37].

Researchers in Wagholi can overlay spatial data on population density and land use to gain insight into human activities that may affect water quality through groundwater analysis[38]. For instance, contamination patterns may be associated with proximity to industrial areas or agricultural lands. Policymakers are able to prioritize conservation efforts and design zoning regulations as a result of this analysis. The efficacy of interventions can be monitored through continuous GIS, ensuring that groundwater remains a safe and reliable resource for the community[39]. In conclusion, the utilization of GIS techniques for the assessment of groundwater quality in Wagholi improves comprehension of environmental challenges, thereby guaranteeing water security and long-term sustainability.

1.4 Water Quality Monitoring

The monitoring of groundwater in the Wagholi Village region is essential due to the potential for contamination from industrial and agricultural activities[40]. Pollutants that impair water quality are introduced by uncontrolled effluent leakage, which exacerbates this issue. The process of monitoring groundwater quality entails the examination of changes in geochemical parameters that are influenced by both natural processes and human activities. In order to identify contamination regions, GIS (Geographical Information System) techniques are implemented to spatially analyze and visualize groundwater data[41]. The purity of water is evaluated by periodically monitoring parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), and nitrate (NO_3).

For example, agricultural discharge contamination, which is predominantly the result of excessive fertilizer use, may be indicated by a substantial increase in nitrate levels that exceed the permissible limit of 45 mg/L (as per BIS standards)[12]. Similarly, electrical conductivity values exceeding 750 µS/cm indicate elevated dissolved salt concentrations, which suggest the presence of industrial effluents. The spatial patterns in water quality deterioration across Wagholi can be identified by mapping these findings using GIS[42]. Seasonal fluctuations in water chemistry, including nitrate maxima during monsoon discharge periods, can be effectively documented through temporal analysis[43].

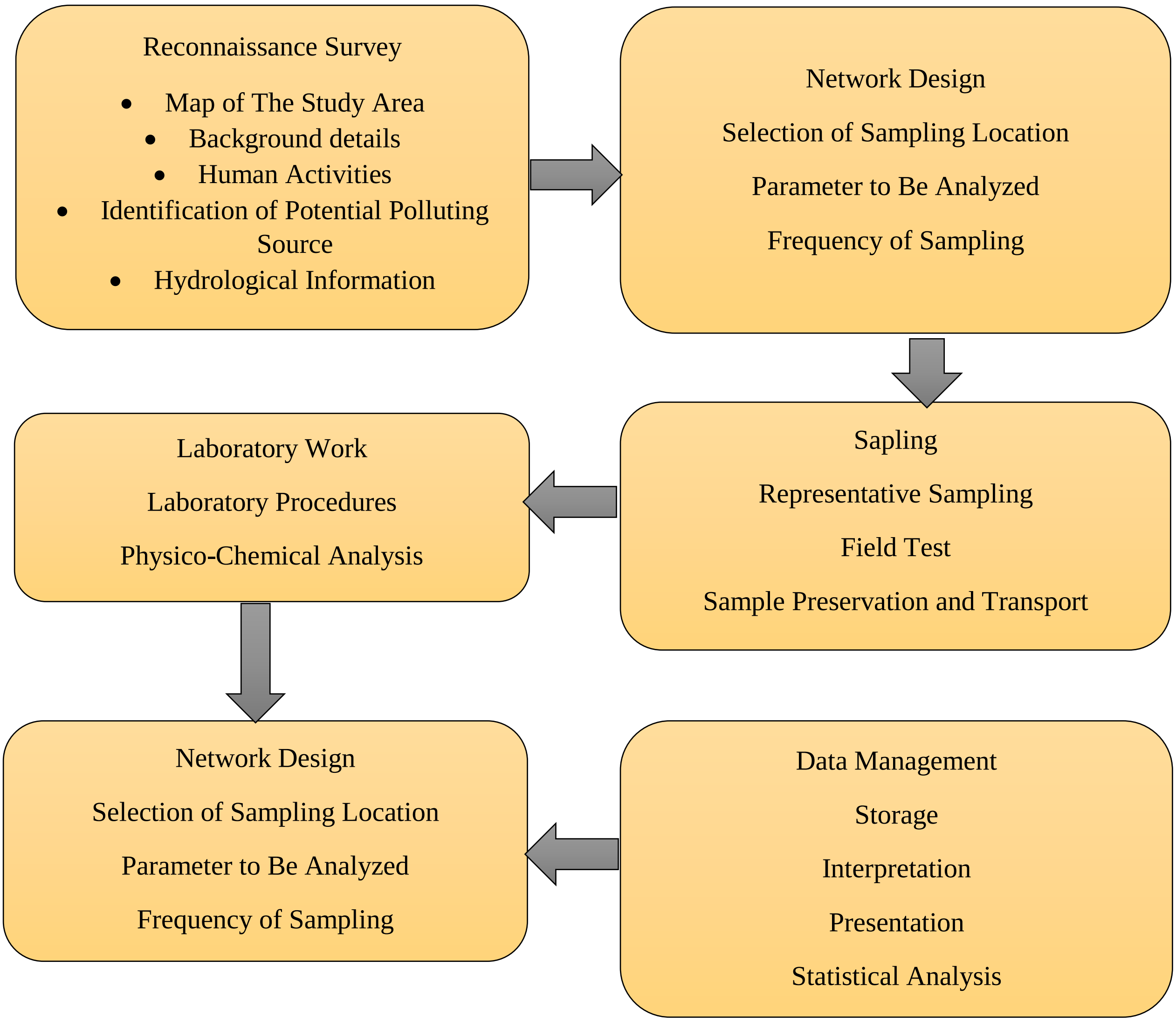

FIG.2 Water Quality Monitoring

II. PAST WORK

Derdour Abdessamed et.al (2023) In March 2022, 43 samples were collected in an arid region (4590.2 km²) to evaluate the purity of groundwater. Sulphates (SO_4^{2-}) as well as calcium (Ca^{2+}) were important constituents. The Water Purity Index (WQI) indicated that the purity of the water was 30.23% exceptional, 62.79% acceptable, and 6.97% inadequate. The correlations demonstrated robust connections between WQI, TDS, EC, TH, SO_4^{2-}, Ca^{2+}, and Mg^{2+}[44]. M.I. Silva et.al (2021) Utilizing data from 22 wells, this investigation evaluated the purity of groundwater in the Araripe Sedimentary Basin, Brazil. In regions with inadequate sewerage systems, parameters such as phosphorus, Nitrate-N, coliforms, pH, as well as turbidity exceeded the established limits. 18.2% of the water was classified as "Regular" by the Water Quality Index, while 82.8% was classified as "Good." Areas for intervention were identified on GIS maps [45]. Hicham Ouhakki et.al (2024) Using 20 physicochemical parameters (e.g., pH, temperature, conductivity, NH_4^+, Na^+, NO_3^-, FeT) as well as microbiological indicators (fecal streptococci, coliforms), the quality of groundwater throughout the Oum Rbia catchment was evaluated. We used GIS-Pro as well as kriging interpolation to analyze samples from 54 sites using WQI as well as MQI. The results indicated that the quality of the groundwater was generally outstanding; however, contamination was particularly evident in the areas that were impacted by effluent [46]. Kaddour Benmarce et.al (2024) Hydrochemical indices and geographic information systems (GIS) were implemented to evaluate the quality of groundwater in the Wadi Boussellam sub-watershed in the Setif region of Algeria. The Sodium Adsorption Ratio (SAR), The Water Quality Index (WQI), as well as The Na% were examined. The results indicate that groundwater is primarily suitable for irrigation, but it is recommending that humans exercise caution when consuming it. This underscores the necessity of consistent monitoring [47].

Amir Bahrami et.al (2024) The study evaluated the purity of groundwater in Fasa Plain, Iran, by analyzing 204 samples that were collected between 2018 and 2019. The water quality index as well as physicochemical parameters were examined. In 2018, 76.05% of the area was classified as outstanding quality; this figure increased to 89.62% in 2019. The southern regions were identified as having a pollution danger due to fertilizers [48]. Fahad Alshehri et.al (2023) The groundwater from 68 wells in Harrat Khaybar, Saudi Arabia, was analyzed. The drinking water limits were surpassed by the average concentrations of Cl–, SO42–, HCO3–, NO3–, Na+, Ca2+, Mg2+, and TDS. In certain samples, PTEs demonstrated Cr, Se, As, Zn, and Pb levels that exceeded acceptable limits. A total of 29 wells were classified as either exceptional or acceptable for drinking [49]. Md. Rezaul Karim et.al (2024) This study employs 15 parameters to examine the trends in groundwater quality over a 35-year period at 18 stations in Dhaka, Bangladesh. Mann-Kendal as well as Sens Slope tests were implemented. High correlations were observed between Mg^{2+} as well as SO_4^{2-}, Na^+ and Cl^-. The use of groundwater is influenced by the dominance of bicarbonate (HCO_3^-) ions, with concentrations ranging from 0.70 to 0.99 [50]. Thangavelu Arumugam et.al (2024) The investigation examined the characteristics of groundwater in Kannur by utilizing 50 samples from between 2011 and 2019. Major anions (HCO3-, CO32−, Cl−, NO3-, SO42−) and cations (TH, Ca2+, Mg2+, Na+, K+, Fe2+) were analyzed. The Water Quality Index (WQI) values were low (4.22%, 8.68%), moderate (17.22%, 18.14%), good (54.14%, 51.56%), and outstanding (24.42%, 21.62%). The eigenvalues of the principal component analysis (PCA) were 84.7% in 2011 and 73.4% in 2019. The accuracy of the WQI maps was found to be declining, particularly in the northwestern region, as indicated by GIS [51].

III. MATERIALS & METHODS

The groundwater samples are carefully collected from bore wells that are approximately equally distributed across 10 locations in Pune district's Wagholi Village. pH, conductivity, chlorides, total alkalinity, fluoride, nitrate, sulphate, total hardness, calcium hardness, as well as magnesium hardness are the parameters that are analyzed during water analysis.

3.1 Water Quality Index (WQI)

For computing WQI, three steps are followed,

Step-1 The parameter nitrate has been assigned a maximal weight of 5 due to its significant role in water quality assessment, and each parameter has been assigned a weight (wi) based on its relative relevance in the overall quality of water for consumption purposes (see table 1). Magnesium that is assigned a minimum weight of 2 may not be detrimental in isolation.

Step-2 The relative weight (Wi) is computed from the following equation:

$$W_i = \frac{wi}{\sum_{i=1}^{n} wi} \quad (1)$$

Where,

Wi is the relative weight,

wi is the weight of each parameter and

n is the number of parameters.

Step-3 A quality rating scale (qi) is assigned to each parameter by dividing its concentration in each water sample by its respective standard in accordance with the BIS's guidelines, as well as the resulting value is multiplied by 100.

$$q_i = \frac{Ci}{Si} x100 \quad (2)$$

Where,

qi is the quality rating

Ci is the concentration of each chemical parameter in each water sample in mg/L

Si is the Indian drinking water standard for each chemical Parameter in mg/l according to the guidelines of the BIS 10500: 1991. For computing the WQI, the SI is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation.

$$SI_i = W_i . qi \quad (3)$$

$$WQI = \sum SIi \quad (4)$$

Where,

SIi is the sub index of ith parameter; qi is the rating based on concentration of ith parameter and n is the number of parameters. The computed WQI values are classified into five types, "excellent water" to "water, unsuitable for drinking". In the Present Study Method-2 was used for calculating the Water Quality Index.

Irrigation water classification

$$\text{Sodium Absorption Ratio (SAR)} = \frac{\text{Na}}{\sqrt{\frac{(\text{Ca+Mg})}{2}}} \quad (5)$$

$$\text{Percent Sodium (\%Na)} = \frac{Na+K}{Ca+Mg+Na+K} \quad (6)$$

TABLE.1 Proportional Weights of Chemical Parameters[52]

Parameter	**Standard (as per BIS)**	**w_i (Weight)**	**W_{in}(Relative Weight)**
pH	6.0-8.5	4	0.125
Chloride (mg/l)	260	3	0.094
Total Hardness (mg/l as $CaCO_3$)	300	2	0.063
Na	150	3	0.094
Sulphate	210	4	0.125
Fluoride (mg/l)	1.5	4	0.125
Nitrate (mg/l)	50	5	0.156
Calcium (mg/l)	75	2	0.063
Magnesium (mg/l)	30	2	0.063
Electric Conductivity (µS/cm)	2000	3	0.094
		$\sum wi = 32$	$\sum Wi = 1.00$

TABLE.2 Water Quality Categories [8]

WQI Value	**Water Quality**
<50	Excellent
50-100	Good Water
100-200	Poor Water
200-300	Very Poor Water
>300	Water Unsuitable for Drinking

3.2 Database

The investigation predominantly relied on spatial maps and field data, with a particular emphasis on the condition of groundwater in Wagholi Village, Pune district. In order to guarantee thorough coverage of the region, groundwater samples were meticulously collected from a variety of locations during the fieldwork. The sampling procedure was facilitated by detailed maps, which guaranteed the systematic and precise collection of data. The reliability and accuracy of the results were guaranteed by the rigorous laboratory testing of the collected samples, which was conducted in accordance with established protocols. The data were meticulously organized and tabulated in an Excel worksheet after testing was completed, which facilitated further interpretation and analysis. The hydrological characteristics of the region were elucidated through a comprehensive examination of groundwater quality, which was facilitated by this structured approach. The results are essential for the development of future water resource management strategies and the comprehension of local groundwater dynamics. The study effectively emphasized the significance of systematic monitoring in hydrological assessments by integrating spatial data with field observations to underscore variations in groundwater quality across different locations.

A. Inverse Distance Weighted

An interpolation method known as Inverse Distance Weighting (IDW) is based on the assumption that values that are closer to the interpolated results have a greater impact on the results than those that are further away. As the distance from the undetermined location increases, the weight ascribed to a known data point decreases. This method is particularly effective when data points are evenly distributed, as it is both efficient and intuitive. Nevertheless, IDW is susceptible to outliers, which can cause results to be distorted, similar to SPLINE functions. The significance of meticulous data selection and management in IDW applications is underscored by the potential for aggregation of unevenly distributed data to introduce substantial errors in the interpolation process.

B. Weighted Overlay

Weighted overlay is a method that applies a standardized measurement scale to a variety of inputs in order to integrate them. This approach entails the overlaying of numerous raster datasets, which enables a thorough examination. The user can assess the combined impact of numerous factors by assigning a weight to each raster based on its significance. The weighted overlay technique enables informed decision-making in spatial analysis while helping in the identification of areas of interest based on multiple criteria by quantifying the importance of each input.

3.3 Analysis Method

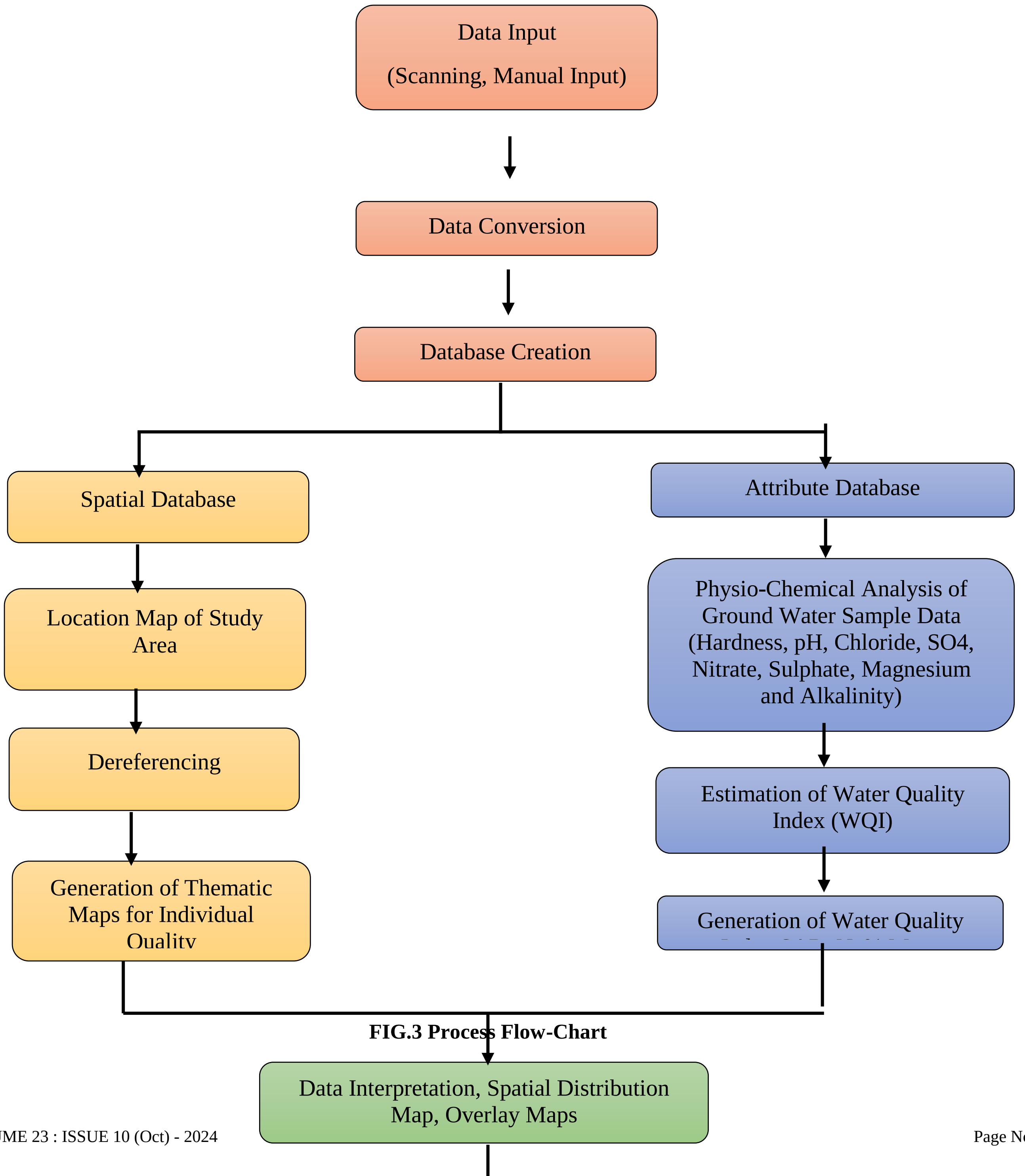

FIG.3 Process Flow-Chart

IV. CASE STUDY

Wagholi is a rapidly developing village located in the Pune district of Maharashtra, India. Situated approximately 20 kilometers northeast of Pune city, Wagholi is known for its strategic location and proximity to various industrial zones, educational institutions, and IT parks. The geographic coordinates of Wagholi are approximately 18.5825° N latitude and 73.9270° E longitude. The population of Wagholi has seen significant growth in recent years, with estimates suggesting around 30,000 residents as of the latest census. The village has a mix of rural and urban characteristics, with traditional farming coexisting alongside modern housing developments. This demographic shift has heightened the demand for groundwater resources, making it essential to assess the environmental quality of this vital water source. Average annual rainfall is about 695mm and the mean daily temperatures range from 38ºC during day and 27ºC at night. The current level of dependency on groundwater is relatively high, and a significant portion of the population prefers to drink it. Ground water will remain a major source of residential water supply for this town due to the insufficiency and concerns regarding the quality of tap water.

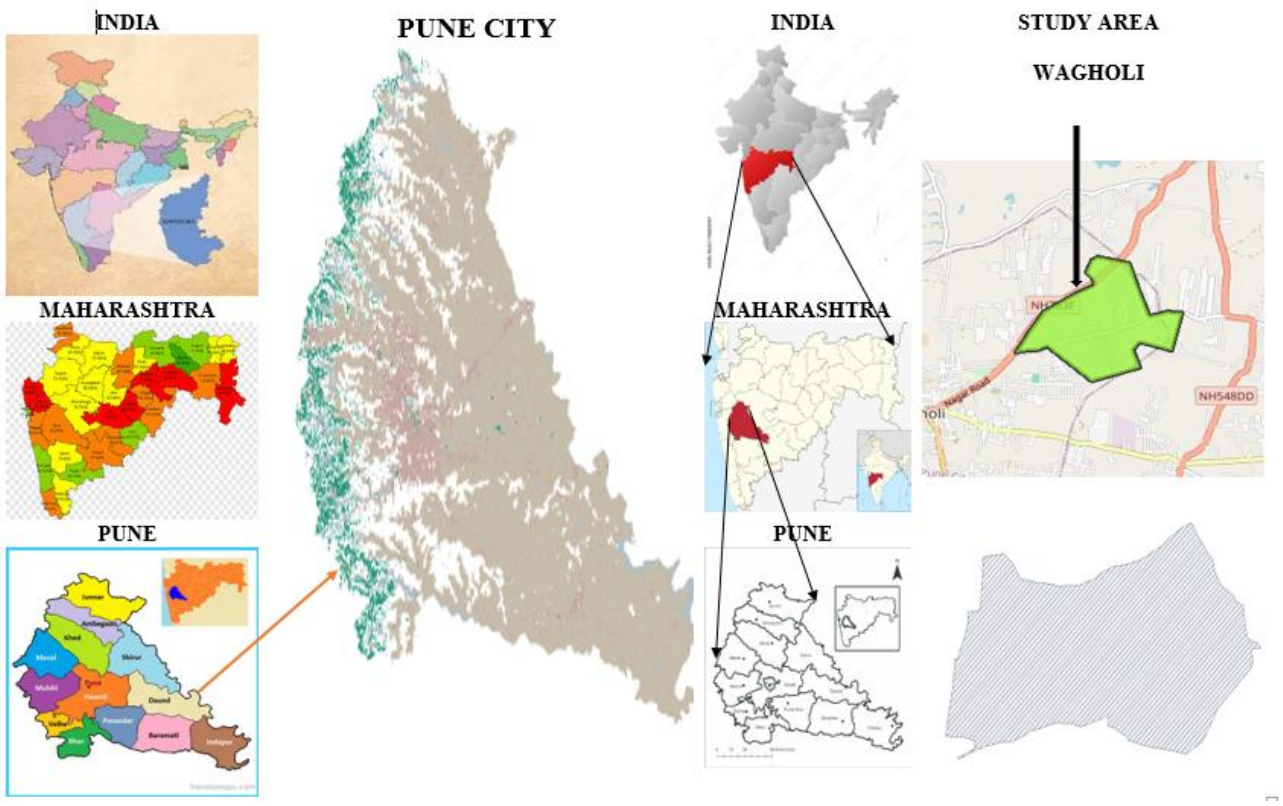

FIG.4 Wagholi Study Area

4.1 Input Parameter

The Pune Municipal Corporation ward map is used to digitize the boundary of the Wagholi Village ward. The 10 channel Garmin handheld GPS was used to locate the groundwater samples. During the collection of the groundwater samples, interviews were conducted with the local population to ascertain the reasons for their use of the groundwater. It was observed that the utilization of groundwater is primarily observed in areas where the municipal corporation water supply is insufficient or non-existent. A shape file of sampling locations is generated using GPS data and attribute information, including water quality parameters such as pH, alkalinity, TDS, Calcium, Magnesium, and others. This file is then associated with the appropriate sampling location following the laboratory analysis.

TABLE.3 Location of Sampling Station

Sample	Latitude	Longitude	Address
S1	18.586277	73.980272	Wagheshwar Temple
S2	18.595979	73.967597	Wagholi Bus Stand

S3	18.584569	73.988703	Satav High School
S4	18.607631	73.9888	Mauli Balak Ashram
S5	18.589735	73.981558	Wagheshwar Sport Club
S6	18.579647	73.994431	Shree Datta Pharma
S7	18.585443	73.971411	Sai Sanskruti Apartment
S8	18.5888	73.9805	President English Medium School
S9	18.5888	73.9808	Talathi Karyalay Wagholi
S10	18.5873	73.9709	Aishwarya Laxmi Apartment

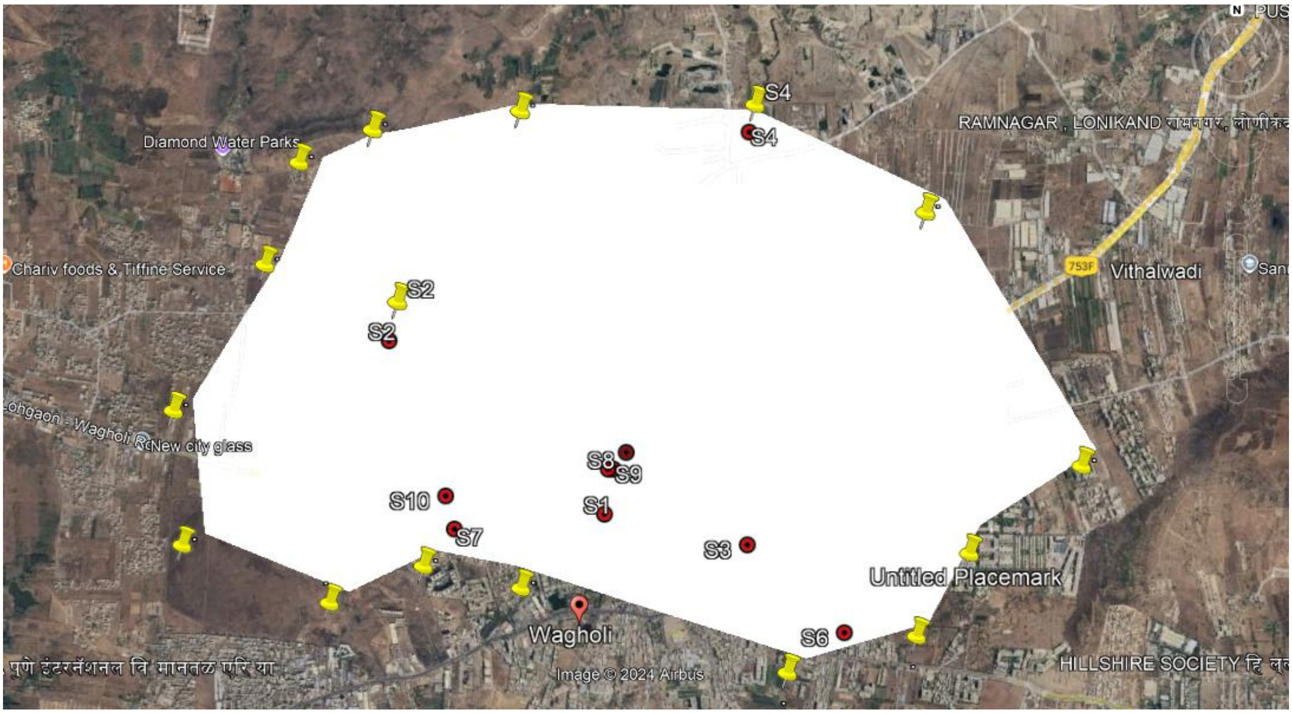

FIG.5 Wagholi Study Area Satellite Image

V. RESULTS AND DISCUSSION

5.1 Water Quality Parameter

TABLE.4 Water Quality Parameter

Sample	pH	EC	Hardness	Calcium	Magnesium	Alkalinity	Chloride	TDS	Nitrate	Sulphate	WQI
S1	7.7	580	421	83	14.58	275	114	160	41.4	135	61.25
S2	7.1	690	280	89	12.3	330	95	140	18	114	57.55
S3	7.6	638	110	74	16	360	71.7	53	13.9	75	25.78
S4	7.9	520	332	86.2	14.5	269	83.4	114	9	39	51.26
S5	7.3	670	103	32.9	18.3	290	110	220	19.4	112	47.35
S6	7.2	712	208	43.8	31	310	188	130	12.3	30	23.25
S7	7.8	633	285	66.7	12	260	103	70	12.7	38	24.77
S8	6.8	703	110	91.2	15.8	283	108	130	12.1	85	40.36
S9	7	648	189	30.7	14	264	163	190	36.2	38	49.85
S10	7.2	540	325	36.8	13.9	273	102	80	11.4	101	57.65

The table 4. water quality parameters for ten distinct samples, which indicate a variety of physicochemical characteristics. The pH values, which range from 6.8 to 7.9, indicate neutral to mildly alkaline conditions. S4 has the maximum pH value of 7.9. The electrical conductivity (EC) is subject to variability, with a climax at 712 µS/cm for S6, which suggests a high ionic content. This can have an impact on the utilization of the water. The presence of dissolved minerals, particularly calcium and magnesium, is underscored by the hardness levels, which range from 103 mg/L in S5 to 421 mg/L in S1. S1 exhibits the maximum calcium content at 83 mg/L. Indicating the ability of water to neutralize acids, alkalinity values range from 260 to 360 mg/L. The Water Quality Index (WQI) is significantly influenced by the nitrate and sulfate concentrations, which vary substantially, while the Total Dissolved Solids (TDS) levels, which reflect the overall water quality, range from 70 to 220 mg/L. It is important to note that S3 has the lowest WQI at 25.78, which suggests that the water quality is inferior to that of the other samples.

5.2 Spatial Distribution of Water Quality Parameter

1. PH

The environmental quality analysis of groundwater in Wagholi Village employs GIS to assess critical parameters, such as pH levels, that determine the water's suitability for a variety of applications. The pH values in the region are within the range of 7.37 to 8.64, which is consistent with the Bureau of Indian Standards as well as the Indian Council of Medical Research's recommended range of 6.5 to 8.5. The analysis suggests that the Northwest region, specifically the vicinity of the Wagholi Village Bus stand, has a concentration of lower pH values. This concentration may be attributed to local geological influences or specific land use. This GIS-based study is essential for the identification of water quality concerns and the development of effective remediation plans.

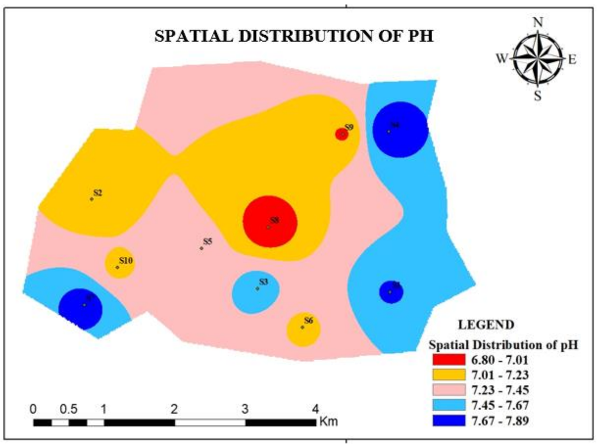

FIG.6 Spatial Distribution of pH

2. Electrical Conductivity (EC)

Geographic Information Systems (GIS) are employed to analyze a variety of parameters, including Electrical Conductivity (EC), in the environmental quality assessment of groundwater in Wagholi Village. The water's capacity to conduct electricity, denoted by EC, is associated with the presence of ionized substances and can indicate issues such as excessive hardness. Significant spatial variations were observed in our investigation, with EC values ranging from 520.2 to 711.98 µm/cm. The western region, particularly Sample sites 1, 4, and 7, exhibited elevated EC levels. It is essential to comprehend these values in order to assess the quality of groundwater for irrigation and potable purposes, as well as to inform effective management and conservation strategies.

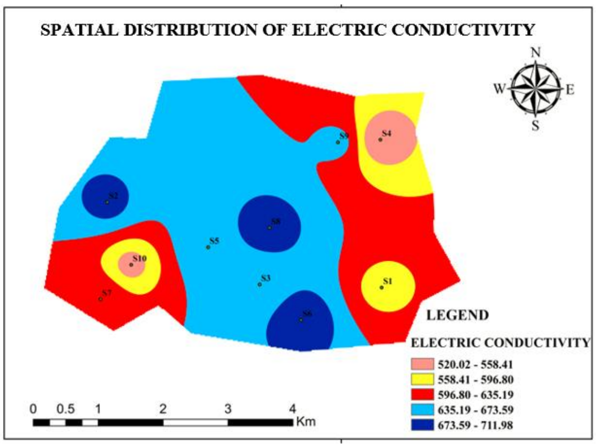

FIG.7 Spatial Distribution of Electrical Conductivity

3. Hardness

A color-coded legend is employed to demonstrate the analysis of water hardness at a variety of sample sites in order to facilitate comprehension. The hardness levels in the areas marked in red (357.39 - 420.98 mg/L) are notably high, particularly in the vicinity of sample S1, suggesting a high mineral content. Samples S6 and S4 exhibit moderately high hardness in dark blue, with values ranging from 293.81 to 357.39 mg/L. Yellow indicates that Sample S3 is classified as moderate hardness (230.22 - 293.81 mg/L). The hardness of samples S7, S8, and S9 is notably lower in light blue areas (166.63 - 230.22 mg/L), whereas samples S2 and S10 exhibit extremely low hardness in magenta (103.05 - 166.63 mg/L). The map indicates a substantial trend of elevated hardness levels in the central and north-eastern regions of the study area, which is essential for the effective administration of water and the evaluation of quality.

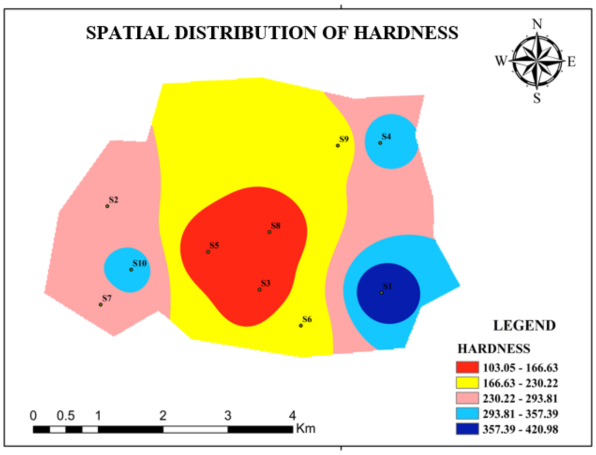

FIG.8 Spatial Distribution of Hardness

4. Calcium

The presence of calcium is a critical water quality indicator in the environmental quality analysis of groundwater in Wagholi Village using GIS. It is frequently present in water and, when combined with magnesium, significantly contributes to its hardness. The investigation demonstrated that the concentration of calcium in the groundwater varied from 30.72 to 91.19 mg/l, with the northwestern region, particularly the vicinity of Satav High School, exhibiting significantly higher levels. The geological and hydrological influences on water quality are illuminated by the variations in calcium levels across various locations. Effective environmental management as well as water resource planning necessitate the identification of these spatial patterns.

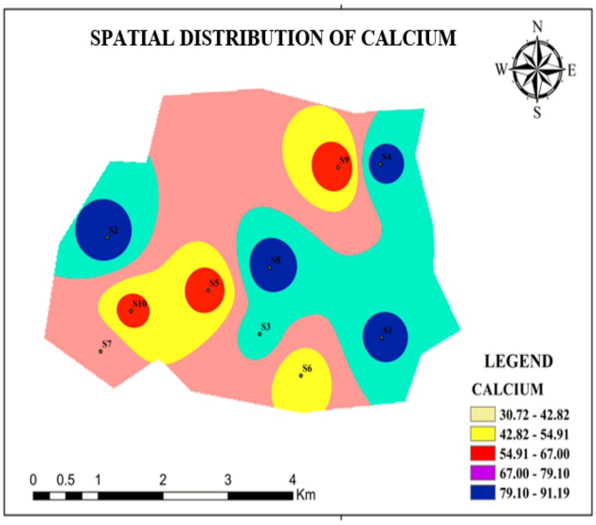

FIG.9 Spatial Distribution of Calcium

5. Magnesium

Figure 10 illustrates the spatial distribution of Magnesium in the groundwater of the Wagholi Village area, which exhibits concentrations that range from 12.00 mg/l to 30.99 mg/l. Magnesium concentrations are highest in specific regions of the subject area. In particular, President English Medium School has been identified as having elevated levels. Furthermore, the Sai Sanskruti Apartment was identified as the study area with inadequate magnesium levels. This spatial analysis indicates that the magnesium content of groundwater in the Wagholi Village area varies in a localized manner. The identification of such distribution patterns is essential for the evaluation of environmental quality and the comprehension of potential impacts on water resources in these specific zones. These findings offer a valuable insight into the geographical distribution of groundwater quality parameters, facilitating targeted interventions for sustainable water management as well as environmental conservation efforts in the region through the use of Geographic Information Systems (GIS).

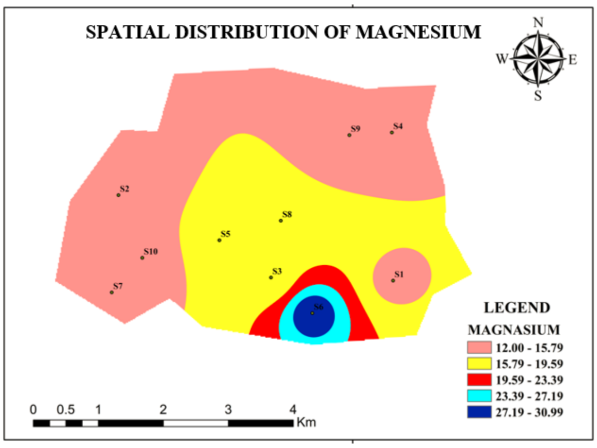

FIG10. Spatial Distribution of Magnesium

6. Alkalinity

The optimal alkalinity level in potable water is approximately 120 mg/l, with a maximum permissible level of 259.98 mg/l. The total alkalinity levels in our study area vary from 120 to 260 mg/l. The alkalinity of Sample No. 3 is particularly high, which may result in ocular irritation in humans and chlorosis in plants. Conversely, Satav High School, which is situated in the north-eastern region, exhibits lower alkalinity levels. This information emphasizes the potential health and environmental consequences of the varying alkalinity levels in various regions.

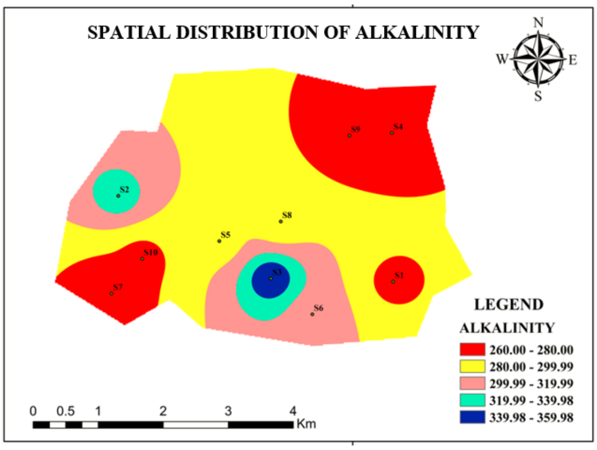

FIG.11 Spatial Distribution of Alkalinity

7. Chloride

Chloride levels are essential for the assessment of water quality; as elevated concentrations frequently indicate increased organic contamination. According to BIS/ICMR guidelines, the maximum permissible concentration of chloride in potable water is 250 mg/l. Chloride levels in the study area ranged from 71.71 to 187.98 mg/l, with maxima at 200 mg/l in the vicinity of Satav High School and Mauli Balak Ashram. These surges may be the consequence of natural events, such as the passage of water through salt deposits or contamination from industrial or residential activities. The north-eastern region of the region exhibited reduced concentrations of chloride, which can induce a cathartic effect.

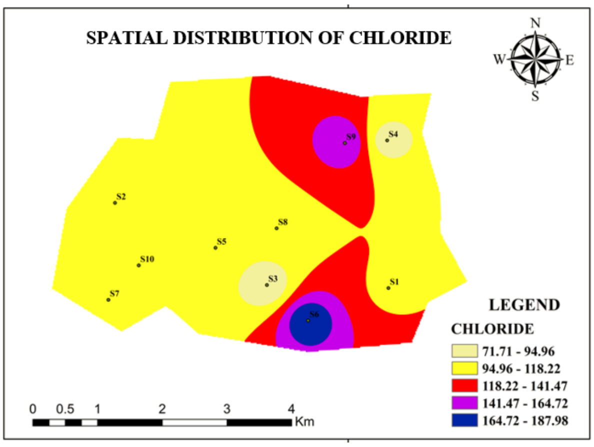

FIG.12 Spatial Distribution of Chloride

8. Total Dissolved Solid (TDS)

Natural elements such as effluent, urban runoff, and industrial discharge are among the numerous sources of total dissolved solids (TDS) in groundwater. A maximum TDS limit of 500 mg/l is recommended by the Indian Council of Medical Research (ICMR) and the Bureau of Indian Standards (BIS). Gastrointestinal complications may result from concentrations that surpass this threshold. The north, east, and west boundaries of our research area exhibit the maximum concentrations of over 190 mg/l, suggesting potential contamination from effluent and discharge into the lake. TDS values in this region range from 186 to 219 mg/l. Elevated TDS was also reported in areas such as Mauli Balak Ashram and Talathi Karyalay Wagholi, which had a detrimental impact on the purity and taste of the water.

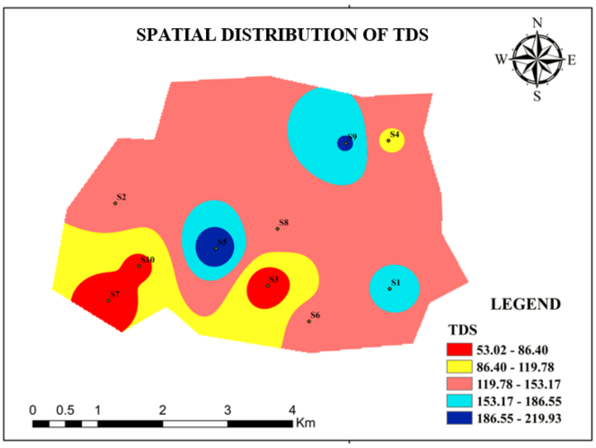

FIG.13 Spatial Distribution of Total Dissolved Solid

9. Nitrate

Nitrate is a critical determinant in the assessment of water quality, as elevated levels frequently indicate a higher level of organic pollution. The BIS/ICMR guidelines establish a permissible chloride limit of 50 mg/l for potable water. Chloride concentrations in the region under investigation ranged from 9.00 to 41.19 mg/l, with a peak of 44.12 mg/l located near Wagheshwar Temple. This variation is likely the result of natural factors, such as water interacting with salt deposits or contamination from industrial or household sources. Laxative effects may result from elevated chloride levels in potable water; however, the north-eastern region of the study area recorded lower levels.

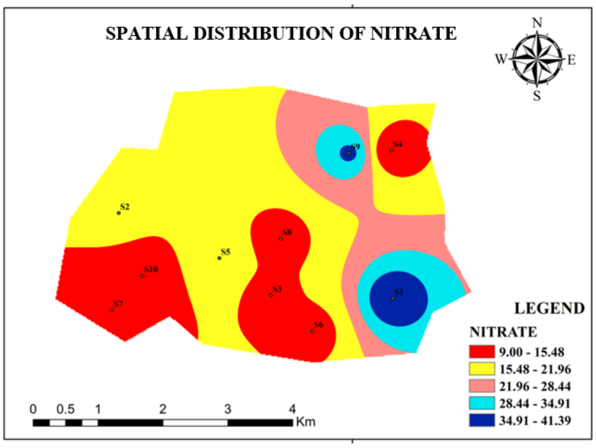

FIG.14 Spatial Distribution of Nitrate

10. Sulphate

The passage elucidates the variable levels of sulfate at various sampling locations by employing a color-coded legend. Near sample S1, the concentration range is at its highest, as indicated by the color cyan (113.99 - 134.99 mg/L). Samples S4 and S9 exhibit elevated sulfate levels in red areas (72.00 - 93.00 mg/L). Samples S5 and S6 exhibit moderate concentrations in the orange zones (51.00 - 72.00 mg/L), while the lowest levels, displayed in yellow (30.01 - 51.00 mg/L), are associated with samples S2, S3, and S10. In general, the map emphasizes substantial spatial disparities in sulfate concentrations, which are essential for comprehending water quality and management.

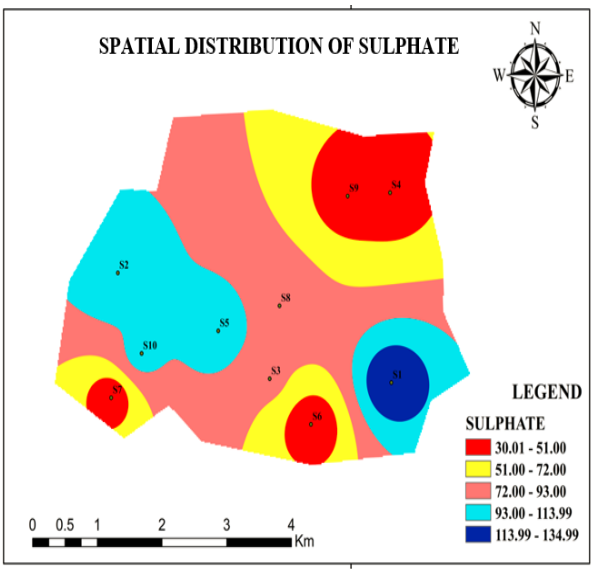

FIG.15 Spatial Distribution of Sulphate

11. Water Quality Index (WQI)

As illustrated in Figure 15, the Water Quality Index (WQI) in the study area ranges from 23.25 to 62. 78.. Wagheshwar Temple exhibits higher WQI values, while Satav High School, Shree Datta Pharma, Sai Sanskruti Apartment, and Talathi Karyalay Wagholi exhibit lower values. The preponderance of groundwater sources in the region are considered safe for drinking as well as are suitable for consumption by the local community, despite these variations.

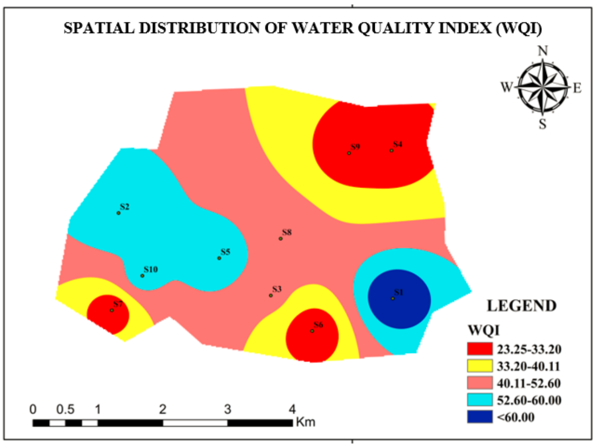

FIG.16 Spatial Distribution of Water Quality Index

VI. CONCLUSION

The environmental quality assessment of groundwater in the Wagholi Village region reveals a significant impact on its suitability for agricultural use and consumption, as it exposes a concerning variability in water quality parameters. The pH values of the ten sampled locations, as shown in Table 4, are neutral to mildly alkaline, with a range of 6.8 to 7.9. Sample S4 exhibited the highest pH, 7.9. The electrical conductivity (EC) ranged from 520 to 712 µS/cm, with S6 exhibiting the highest value. The utilization of water may be compromised due to the potential increase in ionic content, which is indicated by a high EC. The hardness levels varied from 103 mg/L (S5) to 421 mg/L (S1), with the latter indicating an excessive mineral content. The water's capacity to mitigate acids was influenced by alkalinity levels that varied between 260 and 360 mg/L. It is important to note that the Water Quality Index (WQI) fluctuated between 23.25 and 62.78, suggesting substantial variations in water quality. The WQI of Sample S3 was the lowest at 25.78, indicating inadequate water quality. Conversely, higher WQI values were observed in the vicinity of Wagheshwar Temple.

The spatial distribution analysis, which employs GIS techniques, provides valuable insights into the variations in groundwater quality throughout Wagholi Village. For example, the pH levels are primarily neutral to mildly alkaline, with localized variations that suggest anthropogenic influences, particularly in the Northwest region. Areas of elevated ion concentration are identified by the electrical conductivity, which may suggest the presence of contamination sources. Additionally, the analysis of calcium and magnesium levels demonstrates a direct correlation with water hardness, which is subject to variation throughout the study area. Potential pollution sources are indicated by elevated chloride concentrations in the vicinity of Satav High School, underscoring the necessity of effective management strategies. In general, the results emphasize the necessity of ongoing monitoring and evaluation of groundwater quality in Wagholi Village, which will enable the formulation of well-informed decisions for the sustainable management of water resources.

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