

ASSESSMENT OF GROUNDWATER QUALITY USING WATER QUALITY INDEX IN THIRUVALLUR DISTRICT, TAMILNADU.

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Civil Engineering

by

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that the Project Report is the bonafide work of SHAFIQ.M.H (Reg.No.37200068) and VENGATESH.T (Reg. No.37200076) who carried out the project entitled "ASSESSMENT OF GROUNDWATER QUALITY USING WATER QUALITY INDEX IN THIRUVALLUR DISTRICT, TAMILNADU" under my supervision from December 2020 to March 2021.

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Submitted for Viva voce Examination held on _____

Internal Examiner

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DECLARATION

We SHAFIQ.M.H (Reg. No. 37200068) and VENGATESH.T (Reg. No.37200076) hereby declare that the Project entitled “**ASSESSMENT OF GROUNDWATER QUALITY USING WATER QUALITY INDEX IN THIRUVALLUR DISTRICT, TAMILNADU**” done by us under the guidance of Ms P. Eshanthini M.E, at Sathyabama Institute of Science and Technology, Chennai is submitted in partial fulfilment of the requirement for the award of Bachelor of Engineering Degree in Civil Engineering.

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ABSTRACT

In developing countries, the Natural and Man-made environment has an enormous impact. Pollution source increases with the development of cities and causes contamination of air, water and soil. Groundwater serves as the main source of water in the urban environment, which is used for drinking, industrial and domestic purposes and often, it is overexploited. Nowadays the groundwater is facing threats due to anthropogenic activities) Water is the most important in shaping the land and regulating the climate. It is one of the most important compounds that profoundly influence life. The quality of water usually described according to its physical, chemical, and biological characteristics.

The groundwater samples of all the selected stations from the wards were collected for a physiochemical analysis. For calculating present water quality status by statistical evaluation and water quality index, the following 15 parameters have been considered Viz. pH, colour, total dissolved solids. electrical conductivity, total alkalinity, total hardness, calcium, chromium, zinc, manganese, nickel. The obtained results are compared with the Indian Standard Drinking Water specification. The groundwater index is safe for drinking, barring the elevated iron content in certain areas. Based on water quality analysis falls into three general categories: excellent water, good water, poor water.

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CHAPTER- 1

INTRODUCTION

1.1 GENERAL

Water, one among the foremost vital resources, is vital to sustain life. supported the elemental quality, water is employed in several sectors viz. Domestic, agriculture, power and industry. Therefore, one should have some basic information on the number and quality of water resources for his or her proper usage and management. Continuous increase in water demands thanks to increasing population and developmental activities has resulted in additional use of groundwater than the surface water resource which has led to groundwater depletion. Besides this, the groundwater quality is deteriorating because of the disposal of massive industrial effluents and mining activities, as reported by various researchers in several parts of India. the standard of groundwater depends on the composition of the recharge water, the interactions between the water and thus the soil, soil-gas and rocks with which it comes into contact within the unsaturated zone, and therefore the duration and reactions that happen within the aquifer. Therefore, considerable variation is usually found, even within an equivalent general area, especially where rocks of varied compositions and solubility occur. The principal processes influencing water quality in aquifers are physical (dispersion/dilution, filtration and gas movement), geochemical (complexion, acid-base reactions, oxidation-reduction, precipitation solution and adsorption-desorption) and biochemical (microbial respiration and decay, cell synthesis).

1.2 GROUNDWATER QUALITY

Groundwater quality is influenced by the consequences of human activities which cause pollution at the land surface because most groundwater originates by recharge of rainwater infiltrating from the surface. In some cases, water quality concerns can arise quickly from public complaints about odour or taste, an epidemic of water-borne illnesses or widespread death of aquatic species like fish kills. Because many water qualities concerns don't have such obvious or dramatic

consequences, it's going to not be readily apparent that there's a drag . Instead, many important water quality parameters are routinely monitored and compared with water quality standards adopted surely parameters. Water quality standards are adopted to guard various designated uses and are often specific to ecoregions within a state. Ecoregions are simply areas of the state with topographic and geologic similarities.

The analysis of minerals like sodium, potassium and chloride are of great importance to agricultural activities, irrigation, domestic and industrial activities. The water quality parameters of beverage and agricultural use is evaluated from their physicochemical characteristics. The balance of physiochemical properties of water is extremely important for the ecosystem and any imbalance within the physical and chemical constituents of water can harm life. The water streams are subjected to seasonal variation in their physicochemical properties thanks to fluctuation in human and industrial activities and hence continuous monitoring of the physiochemical characteristics of water streams is important to make sure the availability of excellent quality drinking and household water to the human population.

1.3 WATER QUALITY INDEX

Water Quality Index (WQI) is taken into account the foremost effective method of measuring water quality. Several water quality parameters are included during a mathematical equation to rate water quality, determining the suitability of water for drinking. The index was first developed by Horton in 1965 to live water quality by using the ten most regularly used water parameters. the tactic was subsequently modified by different experts. These indices used water quality parameters which vary by number and kinds . The weights in each parameter are supported its respective standards, and therefore the assigned weight indicates the parameter's significance and impacts on the index.

A usual WQI method follows three steps which include.

1. The selection of parameters.
2. Determination of quality function for each parameter.
3. Aggregation through of WQI a mathematical equation.

The index provides one number that represents overall water quality at a particular location and time supported some water parameters. The index enables comparison between different sampling sites. WQI simplifies a posh dataset into easily understandable and usable information. The water quality arrangement utilized in the WQI denotes how suitable water is for drinking. The single-value output of this index, derived from several parameters, provides important information about water quality that's easily interpretable, even by laypeople. during a resource-poor country like Bangladesh where ensuring availability and sustainable management of water is one among the challenging areas towards development.

The present study measures beverage quality with the appliance of the weighted arithmetic WQI method supported some chemical parameters supported IS 10500 (2012). The relevance of this study lies in programmatic implications by providing evidence-based and useful information on beverage quality only. We expect that the findings will help in designing program interventions to make sure safe beverage either by raising awareness about chemical contamination of water or by improving water quality through the supply of hardware supply.

For the calculation of WQI, the permissible values of various physicochemical parameters for the drinking water used in this study are those recommended by the WHO, BIS and ICMR. The WQI value can be calculated by using the following equation.

$$WQI = \sum (W_i q_i).$$

CHAPTER-2

LITERATURE SURVEY

2.1 GENERAL

The following major research programme has been taken from international journals as a reference to analyse the concepts for the project.

2.2 REVIEW OF THE LITERATURE

Abdelkader Bouderbala et al., 2020 Assessment of groundwater suitability for drinking and agricultural purposes was administered within the plain of upper Cliff. The study area covers a neighborhood of 375 km² and lies during a semiarid climate. Groundwater is that the major source of domestic and agricultural activity during this area. Groundwater samples were collected from 19 wells during dry and wet periods in 2012, and that they were analyzed for major cations and anions and compared with drinking and irrigation specification standards. The concentration of the bulk of chemical constituents exceeds the standards of WHO as a results of various sources of pollution. It indicates the dominance of groundwater types: Ca-Mg-Cl, and CaMg-HCO₃. The suitability of groundwater for drinking was evaluated supported the water quality index; it shows quite 60% of samples have very poor quality for dry and wet periods, which suggests water is severely contaminated and unsuitable for drinking purpose. In terms of irrigation usage, generally, groundwater is suitable for both periods within the major a part of the plain. The Mineralization processes during this area are determined by the lithology of the aquifer (exchange water-rock), anthropogenic factors (discharges of urban sewage, use of fertilizers) and also by evaporation (semi-arid climate).

Mufidal-hadith et al. 2019, Water Quality Index has been applying within the present study to assess the suitability of groundwater quality for drinking purposes in Ratmao –Pathri Rao Watershed, Haridwar District, India. This was administered by subjecting twenty-one groundwater samples, collected from eleven selected site to comprehensive Physico-chemical analysis. Nine parameters are considered for calculating the WQI

like pH, total hardness, calcium, magnesium, bicarbonate, chloride, nitrate, sulphate, and total dissolved solids. The computed WQI shows that 48% of the water sample falls in excellent categories and 48% falls within the good water category. On the opposite hand, one site located at Teliwala village which represents 4% falls in very poor categories. Such waters aren't suitable for drinking purposes under normal condition and further action for salinity control is required. The high value of WQI at this site is especially thanks to the upper values of TDS, Ca^{2+} , K^{+} , Cl^{-} , HCO_3^{-} , NO_3^{-} and SO_4^{2-} where it had been found that there's a really high coefficient of correlation between them

Moustafa El Baba et al., 2019 Groundwater contamination may be a major problem within the Gaza Strip . during this study, we investigate the groundwater quality within the Dier al-Balah Governorate. Water samples were collected from 19 municipal wells in April 2009 and April 2014 and analyzed for physio-chemical parameters (pH, TDS, Ca^{2+} , Mg^{2+} , Na^{+} , K^{+} , Cl^{-} , SO_4^{2-} , HCO_3^{-} and NO_3^{-}). The research aims to work out the groundwater quality and to supply groundwater quality maps using the water quality index (WQI) method and geostatistical analysis. The results show that each one water samples are very saline thanks to the intrusion of Mediterranean seawater within the coastal aquifer. Differences in chemical composition between 2009 and 2014 indicate that about 1% more seawater was mixed with the groundwater during this period. Most of the observed chemical parameters of all wells are well above the WHO water quality standards and every one WQI values indicate that the water quality is problematic. The spatial variation of the WQI scores is modelled by a deterministic component expressing a linear dependence on the space to the coastline and a stochastic residual described by an exponential variogram with a practical range of 3000 m. The mapping of the WQI scores and derived water quality classes is achieved through regression-kriging. The results indicate that the groundwater during a large area along the coastline is unsuitable for human consumption and a comparison of the maps of 2009 and 2014 shows that this region further expanded by about 700 m inland in 5 years. The results of this study are worrying, but they

also contribute to a far better understanding of the factors that determine the groundwater quality and may help authorities and stakeholders with sustainable development.

Ehsan Fathi et al., 2018 evaluates the water quality of the Beheshtabad River in Iran's Chaharmahal and Bakhtiari Province, using water quality index and multivariate statistical methods. Nitrate, temperature, phosphate, turbidity, dissolved oxygen, biological oxygen demand, electrical conductivity, total solids, and pH were measured at five selected stations along the river over 6 months using standard methods. Water quality index results demonstrated that water quality varied within the selected stations between average and good which pollution during this section of the Beheshtabad River increases from upstream to downstream. Clustering and principal component analysis were also utilized. Multivariate statistical methods were used to analyse water conditions for the efficient management of surface water quality. Agricultural fertilizers, upstream wastewater discharge, and fish farms constitute the most elements that decrease the water quality of the Beheshtabad River. To preserve this water resource against pollution, the implementation of stringent rules and guidelines are needed to reinforce health and preserve water resources for future generations.

Gopal Krishan et al., 2017 A water quality index (WQI) numerically summarizes the knowledge from multiple water quality parameters into one value that's understandable and usable by the general public. This information is often used to assess spatial and temporal variations in overall water quality. However, these indices are time and region-specific and should be influenced by local factors. Muzaffarnagar and Shamli districts of Uttar Pradesh are situated in Ganga-Yamuna doab of fertile alluvium of Indo-Gangetic basin where the stress for surface water and groundwater are growing with the rapid increase in agricultural and industrial activities. Within the present study, the water quality index is figured out to assess the spatial variation of groundwater quality status for future planning and management of Muzaffarnagar and Shamli districts using WQI. Data of 104 groundwater samples covering the entire districts

are used. The Water Quality Index has been computed using five parameters viz., pH, Total Dissolved Solids, Total Hardness, Chloride and Sulphate. The WQI results show that the general water quality class is 'good' and water is suitable for domestic use.

Smita Rout et al., 2016 conducted a study to assess and ascertain the physio-chemical properties of Mahanadi river water from five different locations of (Binakhandi, 500 m upstream of Binakhandi, 500 m downstream of Binakhandi, PC bridge and Dhanupali) Sambalpur city of Odisha during March and August 2014. The analysis was administered by taking certain important parameters like pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), Chloride, total dissolved oxygen (TDS), Nitrate, Sulphates, total hardness (TH), electrical conductivity (EC) and Fluoride. Analysed parameters like pH, DO, TH, Chloride, Sulphate, and TDS were found within the permissible limit prescribed by IS 10500 except Nitrate and Fluoride content which exceeds at some sites

Gopal Krishan et al., 2016 discussed the Water quality index (WQI) of groundwater supported the info of 27 samples collected from Rajkot district, Gujarat was assessed using seven parameters viz. pH, Total Dissolved Solids, Total Hardness, Fluoride, Chloride, Sulphate and Nitrate. The WQI value 98 is that the maximum and therefore the value 27 is that the minimum within the study area. The computed WQI shows that 51.8% of water sample fall within the 'good' to 'excellent' water category, on the opposite hand, 48.2% of water samples fall within the 'fair' to 'poor' category indicating that the water isn't suitable for direct consumption and need treatment. After treatment, the water are often used for drinking purpose.

Tahera Akteretal., 2016 conducted a cross-sectional study in 24 randomly selected Upazilas, arsenic was measured in beverage within the field using an arsenic testing kit and a sub-sample was validated within the laboratory. Water samples were collected to check water pH within the laboratory also as a sub-sample of collected beverage was tested for water

pH employing a portable pH meter. For laboratory testing of other chemical parameters, iron, manganese, and salinity, beverage samples were collected from 12 out of 24 Upazilas beverage at sample sites was slightly alkaline ($\text{pH } 7.4 \pm 0.4$) but within acceptable limits. Manganese concentrations varied from 0.1 to 5.5 mg/L with a median of 0.2 mg/L. The median iron concentrations within the water exceeded WHO standards (0.3 mg/L) at the most of the sample sites and exceeded Bangladesh standards (1.0 mg/L) at a couple of sample sites. Salinity was relatively higher in coastal districts. After laboratory confirmation, arsenic concentrations were found higher in Shibchar (Madaripur) and Alfadanga (Faridpur) compared to other sample sites exceeding the WHO standard (0.01 mg/L). Of the entire sampling sites, 33 available good-quality water for drinking supported the Water Quality Index (WQI). However, the bulk of the households (67 %) used poor-quality beverage . Higher values of iron, manganese, and arsenic reduced beverage quality. Awareness-raising on chemical contents in beverage at the household level is required to enhance public health.

N.Rahmanian et al., 2015 investigated the suspected parts of Perak state, Malaysia, to make sure the continual supply of unpolluted and safe beverage for public health protection. during this regard, an in depth physical and qualitative analysis of beverage samples was administered in several residential and commercial areas of the state. Several parameters like pH, turbidity, conductivity, total suspended solids (TSS), total dissolved solids (TDS), and heavy metals like Cu, Zn, Mg, Fe, Cd, Pb, Cr, As, Hg, and Sn were analysed for every water sample collected during winter and summer periods. The obtained values of every parameter were compared with the quality values set by the planet Health Organization (WHO) and native standards like National beverage Quality Standard (NDWQS). The values of every parameter were found to be within the safe limits set by the WHO and NDWQS. Overall, the water from all the locations was found to be as safe as beverage . However, it's also important to research other potential water contaminations like chemicals and microbial and radiological materials for a extended period, including physical body fluids, to assess the general water quality of the Perak state.

Suneetha.M et al., 2015 explained that Water Quality Index (WQI) is to show complex water quality data into information that's clear and useful for the community. The aim was to calculate the WQI for the groundwater samples collected in Vinukonda Mandal of Guntur District. WQI is an efficient tool to assess the suitability of groundwater quality for drinking purposes by providing one number supported various physicochemical parameters. WQI is calculated to understand the general groundwater quality status of the study area and therefore the values range from 130.97 to 206.59. Then its quality is categorized supported different conditions including excellent, good, poor, very poor and unfit.

Robert Damo et al., 2015 this study aims to work out the standard of beverage within the city of Pogradec, Albania. Daily samples were taken from six fixed points within the city. They were analyzed supported the quality methods for the subsequent parameters: taste, odour, temperature, pH, conductivity (EC), turbidity, NO_3^- , NO_2^- , NH_4^+ , chloride, and microbial load. The assessment of water quality was made using the water quality index (WQI) of the Canadian Council of Ministries of the Environment (CCME). The calculated value of CCME WQI by 87.81 indicates that the beverage quality within the city of Pogradec is "good," which turbidity is that the main problem in quality.

Shriram Deshpandae et al., 2014 studied the water quality index (WQI) for the groundwater of Indore City and its industrial area. The groundwater samples of all the chosen stations from the wards were collected for a physiochemical analysis. For calculating present water quality status by statistical evaluation and water quality index, the subsequent 15 parameters are considered Viz. pH, colour, total dissolved solids, electrical conductivity, total alkalinity, total hardness, calcium, chromium, zinc, manganese, nickel. The obtained results are compared with the Indian Standard beverage specification IS 10500-2012.

G.Venkatesan et al., 2014 analyzed the samples collected for testing their chemical parameters. These parameters are helping to point the extent of quality of ground and surface water for drinking and other

domestic purposes. Several parameters like pH, turbidity, conductivity, total suspended solids (TSS), total dissolved solids (TDS), and heavy metals like Cu, Zn, Mg, Fe, Cd, Pb, Cr, As, Hg, and Sn were analysed for every water sample collected during winter and summer periods. The obtained values of every parameter were compared with the quality values set by the planet Health Organization (WHO) and native standards like National beverage Quality Standard (NDWQS). The values of every parameter were found to be within the safe limits set by the WHO and NDWQS.

Ali Bawasheakh Ahmad et al., 2012 This study was conducted over seven villages near Darbandikhan district including (2) wells and (5) springs. It covers quite 60 km², to assess the suitability of groundwater quality for drinking purpose employing a water quality index through investigating of various wells and springs; this system may be a very useful gizmo for quick assessment for any water system. This was done by subjecting the seven water resources within the mentioned area under investigation, where beverage samples aren't treated before consumption. For calculating Water Quality Index, fourteen parameters like (pH, TDS, EC, Turbidity, Total Hardness as CaCO₃, Calcium, Magnesium, Sulphate, Chloride, Nitrate (NO₃-N), Nitrite (NO₂-N), Phosphate (PO₄-P), Sodium and Potassium) are considered. The study cover two seasons namely fall and spring. The observed values of those physicochemical parameters were compared with World Health Organization standards. The results indicated that the water quality of springs and wells varied from excellent water quality (A) to good water quality (B).

Zhao Wu et al., 2011 Twenty-four samplings were conducted every 3 months at 15 sites from in Lake Poyang, and 20 parameters were analyzed and classified into three groups (toxic metals, easily treated parameters, and others). The assessment results supported the water quality index (WQI) showed that the water quality in Lake Poyang was generally “moderate”, consistent with the classification of the surface water quality standard (GB3838-2002) in China, but a deteriorating trend was observed at the interannual scale. Seasonally, the water quality was best in summer and worst in winter. Easily treated parameters generally determined the

WQI value within the assessment, especially total nitrogen (TN) and total phosphorus (TP), while toxic metals and other parameters in Lake Poyang were generally at low and safe levels for beverage . Water level (WL) features a net positive effect on water quality in Lake Poyang through dilution of environmental parameters, which in practice means TN. Consequently, local management agencies should pay more attention to nutrient concentrations during the monitoring schedule, also as during the low-water periods which manifest a comparatively bad water quality state, especially with the prevailing low WL observed recently in Lake Poyang.

Abdul Hameed M et al., 2010 applied the Water Quality Index (WQI) in Dokan Lake, Kurdistan region, Iraq using ten water quality parameters (pH, Dissolved Oxygen, Turbidity, Conductivity, Hardness, Alkalinity, Sodium, Biochemical Oxygen Demand, Nitrate and Nitrite). The relative weight assigned to every parameter ranged from 1 to 4 supported the importance of the parameter for aquatic life. The results indicated that the water quality of Dokan Lake declined from Good within the years 1978, 1979, 1980, 1999, 2000 and 2008 to Poor in 2009. The impact of varied anthropogenic activities was evident on some parameters like the EC and BOD. it's suggested that monitoring the lake is important for correct management. Application of the WQI is additionally suggested as a really helpful tool that permits the general public and decision-makers to guage the water quality of lakes in Iraq.

Ashwani Kumar et al., 2009 evaluated the water quality of River Ravi, a tributary of the Indus System by the Water Quality Index (WQI) technique. A water quality index provides one number that expresses overall water quality at a particular location and time supported several water quality parameters. the target of an index is to show complex water quality data into information that's understandable and useable by the general public . Eight most vital parameters like pH, total dissolved solids (TDS), total hardness, calcium (Ca), magnesium (Mg), total alkalinity, dissolved oxygen (DO) and electrical conductivity (EC) were taken for the calculation of WQI. The WQI values for the River Ravi ranged from 54.8 to 97.88. The values of WQI showed that the water was freed from any

impurities at the sampling site apart from 2-3 months where its values were but 70. Whenever there are human activities e.g., dam operations, water gets polluted to some extent, therefore the value of WQI decreases. It had been found that the parameter which is required within the slightest contributes to a high statistical value to the index. It's concluded that WQI are often used as a tool in comparing the water quality of various sources. It gives the general public a general idea of the possible problems with water during a particular region. The indices are among the foremost effective ways to speak the knowledge on water quality trends to the general public or the policymakers and water quality management.

Rama Krishnaiah C.R et al., 2008 assessed the water quality index (WQI) for the groundwater of Tumkur taluk. This has been determined by collecting groundwater samples and subjecting the samples to a comprehensive physicochemical analysis. For calculating the WQI, the subsequent 12 parameters are considered: pH, total hardness, calcium, magnesium, bicarbonate, chloride, nitrate, sulphate, total dissolved solids, iron, manganese and fluorides. The WQI for these samples ranges from 89.21 to 660.56. The high value of WQI is especially from the upper values of iron, nitrate, total dissolved solids, hardness, fluorides, bicarbonate and manganese within the groundwater. The results of analyses are wont to suggest models for predicting water quality. The analysis reveals that the groundwater of the world needs a point of treatment before consumption, and it also must be shielded from the perils of contamination

CHAPTER-3

AIM AND SCOPE

3.1 AIM

- To understand the importance of groundwater and underground water quality
- To collect the groundwater sample from the study area.
- To test and analyses the different types of physicochemical characteristics.
- To calculate the water quality index for the study area.

3.2 SCOPE

Collection of the water sample, assessment of water quality by chemical and physical methods. Analysis and monitoring of water quality by water quality standards. Analysis of groundwater which is borewell by testing the physicochemical parameter and comparing the result with the permissible limit. Finalizing the water quality status which is good quality or poor quality.

CHAPTER- 4

MATERIALS AND METHODS

4.1 STUDY AREA

Thiruvallur is located in the north of Chennai city, Tamilnadu, Indian and it is bounded by the Kosathaliyar river, Thiruvallur creek and Bay of Bengal. The creek separates Thiruvallur from the Thiruvallur port and athipattu puthunagar. The average annual rainfall in the study area is 140 cmlt and was recently merged with Chennai city. Thiruvallur surrounded by the hub range of industrial projects, mainly thermal power stations and industrials ports. Fig 4.1 shows the study area map.

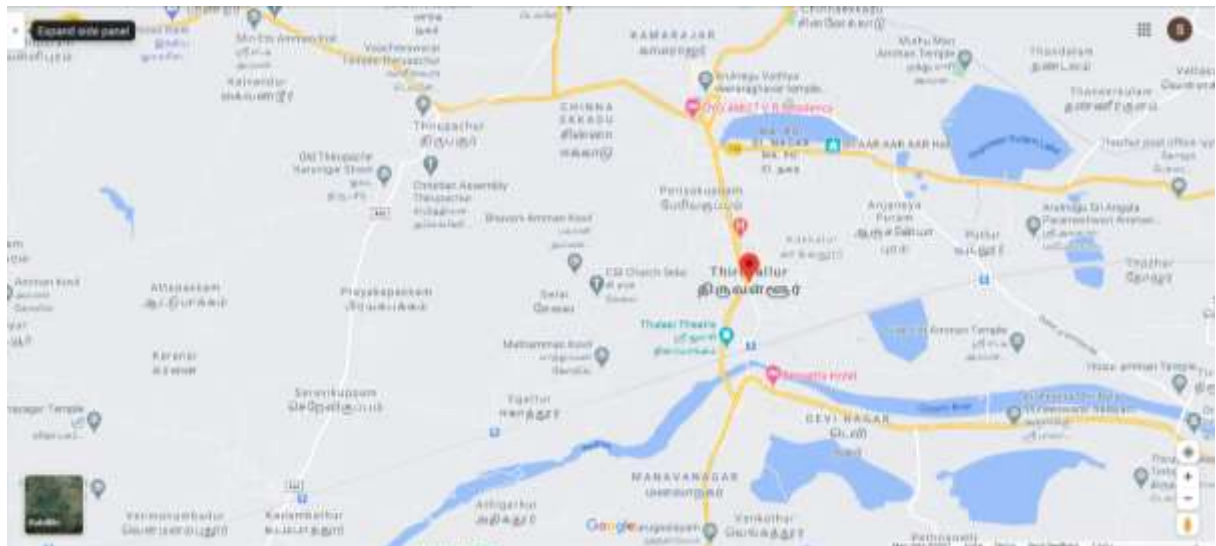


Fig 4.1: study area map

4.2 METHODOLOGY

The methodology of this project includes the collection of samples, testing of samples and development of the water quality index. Fig 4.2 shows the methodology of the work.

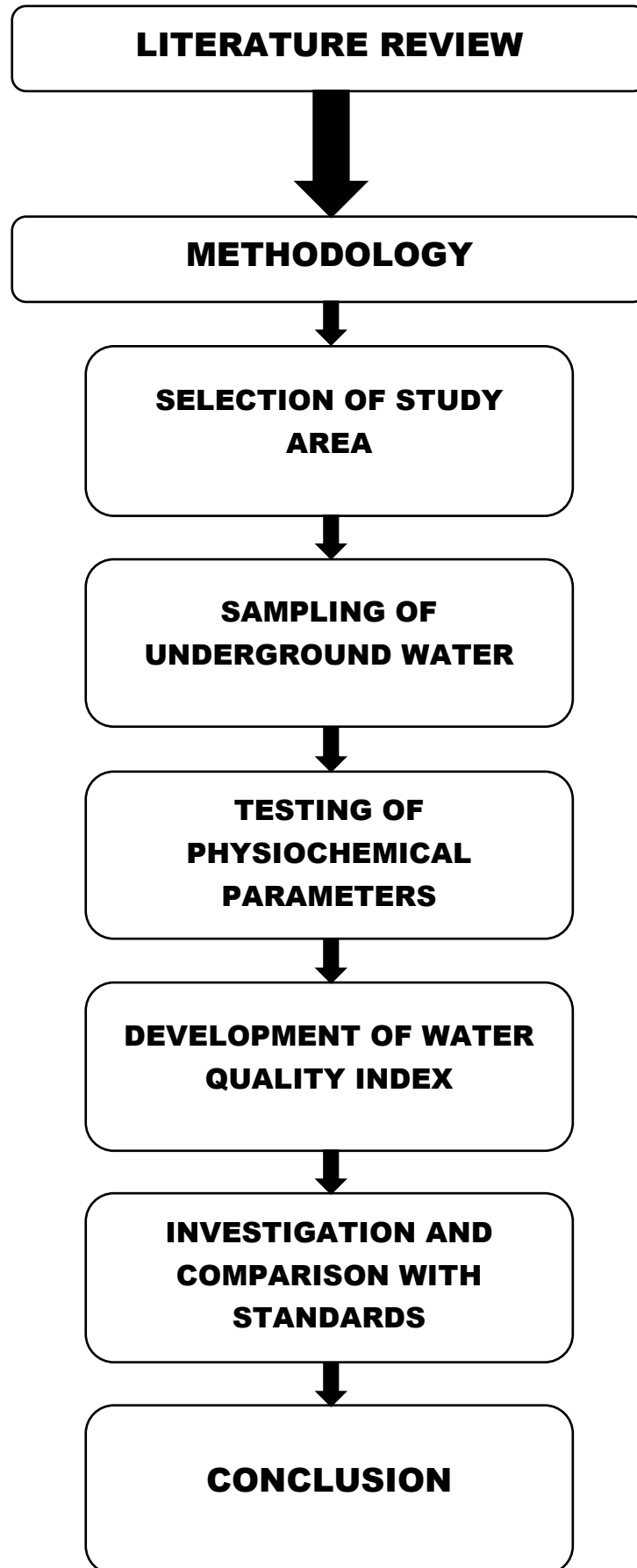


Fig 4.2: METHODOLOGY

4.3 SAMPLE COLLECTION

Ten samples were collected for assessment of groundwater quality during the post-monsoon season from different bore wells which are represented in table 3.1. Groundwater samples were collected in clean polyethene bottles. At the time of sampling, bottles were thoroughly rinsed two or three times with groundwater to be sampled. The water samples were collected after flushing water for 10-15 minutes to remove the stagnant water as per standard procedures. Fig 4.3 and Fig 4.4 shows the sampling location of the study area.



Fig:4.3: Sampling location of the study area



Fig: 4.4: Sampling location of the study area

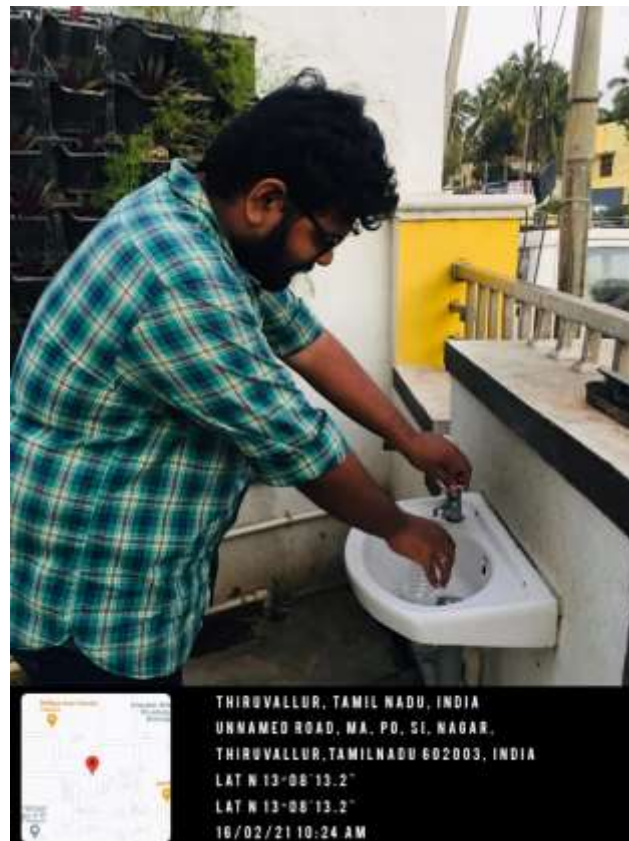


Fig:4.5 Picture of sampling Location



Fig:4.6 Picture of sampling Location

Table: 4.1: Details of sampling locations

S. No	LOCATIONS	SAMPLING CODES	LATITUDES	LONGITUDES	SOURCE
1.	Kakulur Avadi bypass	Sample 1	13.1370	79.9198	borewell
2.	Chinna Kaadu	Sample 2	13.1441	79.9187	borewell
3.	Mahalakshmi Nagar	Sample 3	13.1441	79.9180	borewell
4.	Kakulur sipcot	Sample 4	13.1310	79.9312	borewell
5.	Ramapuram main road	Sample 5	13.7582	79.5641	borewell
6.	Ikadu kakulur	Sample 6	13.1384	79.9291	borewell
7.	Ikadu kakulur	Sample 7	13.1383	79.9287	borewell
8.	Poonga Nagar	Sample 8	13.1201	79.9227	borewell
9.	Nggo colony	Sample 9	13.1202	79.9230	borewell
10.	Maruthi new town	Sample 10	13.1251	79.9259	borewell

Table:4.2 the distance between the samples

SNo.	SAMPLES	<i>DISTANCE (Km)</i>
1	Sample 1 to sample 2	3.2
2	Sample 2 to sample 3	4.4
3	Sample 3 to sample 4	5.8
4	Sample 4 to sample 5	4
5	Sample 5 to sample 6	3.5
6	Sample 6 to sample 7	4.1
7	Sample 7 to sample 8	1
8	Sample 8 to sample 9	2.5
9	Sample 9 to sample 10	1

4.4 TESTING OF SAMPLES

Water temperature was measured on the location employing a mercury-in-glass thermometer while other parameters were determined within the laboratory within 48 to 72 hrs of the sampling following the standards. the subsequent 13 water quality parameters were tested for the collected samples which include Electrical Conductivity (EC), pH, Calcium (Ca²⁺), Magnesium (Mg²⁺), Sodium (Na⁺), Potassium (K⁺), Bicarbonates (HCO₃⁻), Sulphate (SO₄²⁻), Chloride (Cl⁻), Nitrate (NO₃⁻), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA) and table 4.3 shows the methods adopted to check different water quality parameters.

Table: 4.3: Sampling Methods

<u>S. No</u>	<u>Tests</u>	<u>Units</u>	<u>Methods</u>
1.	E.C	uS/Cm	IS 3025 (part 14)-1983 (R.2006)
2.	pH	-	IS 3025 (Part 11)-1983 (R.2017)
3.	Calcium	mg/l	IS 3025 (Part 40)-1991 (R.2014)
4.	Magnesium	mg/l	IS 3025 (Part 46)-1994 (R.2014)
5.	Sodium	mg/l	IS 3025 (Part 22)-1994 (R.2014)
6.	Potassium	mg/l	IS 3025 (Part 33)-1994 (R.2014)
7.	Bicarbonate	mg/l	IS 3025 (Part 21)-2009 (R.2014)
8.	Sulphate	mg/l	IS 3025 (Part 24)-1986 (R.2014)
9.	Chloride	mg/l	IS 3025 (Part 32)-1988 (R.2014)
10.	Nitrate	mg/l	IS 3025 (Part 46)-1994 (R.2014)
11.	TDS	mg/l	IS 3025 (Part 16)-1984 (R.2017)
12.	Total Hardness as CaCO ₃	mg/l	IS 3025 (Part 21)-2009 (R.2014)
13.	Total Alkalinity as CaCO ₃	mg/l	IS 3025 (Part 23)-1986 (R.2014)

Table 4.4 Laboratory testing results

S.NO	TESTS	UNITS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1.	E.C	uS/cm	1940	1820	3320	2580	2080	1980	2187	1550	1290	3290
2.	pH	-	6.6	6.9	6.6	6.8	7.1	7.3	7.1	7.5	7.1	7.3
3.	Calcium	Mg/l	86	94	168	132	92	97	110	104	88	224
4.	Magnesium	Mg/l	56	35	153	51	90	57	68	49	44	146
5.	Sodium	Mg/l	230	232	258	297	191	176	146	127	113	206
6.	Potassium	Mg/l	20	21	38	20	20	27	34	31	0	29
7.	Bicarbonate	Mg/l	336	488	153	610	427	552	650	305	281	464
8.	Sulphate	Mg/l	28	39	381	52	29	46	68	37	61	52
9.	Chloride	Mg/l	319	284	652	411	362	399	241	280	252	787
10.	Nitrate	Mg/l	154	49	145	152	144	112	70	84	0	91
11.	TDS	Mg/l	1063	999	1873	1421	1142	965	1178	865	699	1767
12.	TH	Mg/l	445	380	1050	540	600	780	867	460	400	1160
13.	Total alkalinity	Mg/l	275	400	125	500	350	187	378	250	230	380

4.4.1 Electrical Conductivity

The conductivity of a substance is defined as 'the ability or power to conduct or transmit heat, electricity, or sound'. Its units are Siemens per meter [S/m] in SI and millimhos per centimetre [mm ho/cm] in U.S. customary units. Its symbol is k or s. Electrical conductivity (EC).

4.4.2 pH

pH may be a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral. pHs of but 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH may be a measure of the relative amount of free hydrogen and hydroxyl ions within the water

4.4.3 Calcium (Ca^{2+}) and Magnesium (Mg^{2+})

The straightforward definition of water hardness is that the amount of dissolved calcium and magnesium within the water. water is high in dissolved minerals, both calcium and magnesium. When water is heated, like during a home hot-water heater , solid deposits of calcium and magnesium carbonate can form.

4.4.4 Sodium (Na^+)

A soft, light, extremely malleable silvery-white element that's an alkaline metal , reacts violently with water, is of course abundant in combined forms, especially in common salt, and is employed within the production of a good sort of industrially important compounds.

4.4.5 Potassium (K^+)

Potassium compounds could also be water-soluble. Examples are salt with a water solubility of 115 g/L, permanganate of potash with a water solubility of 76 g/L, iodide with a water solubility of 92 g/L, and iodide , of which even up to 1480 g could also be dissolved in one litre of water.

4.4.6 Bicarbonates (HCO_3^-)

The method of raising the concentrations of carbonate and bicarbonate ions in water to supply soda water and other carbonated beverages – either by the addition of CO_2 gas struggling or by dissolving carbonate or bicarbonates.

4.4.7 Sulphate (SO_4^{2-})

Sulphate is one among the main dissolved components of rain. High concentrations of sulphate within the water we drink can have a laxative effect when combined with calcium and magnesium, the 2 commonest constituents of hardness.

4.4.8 Chloride (Cl^-)

It's formed when the element chlorine (a halogen) gains an electron or when a compound like acid is dissolved in water or other polar solvents. Chloride salts like common salt are often very soluble in water.

4.4.9 Nitrate(NO_3^-)

Nitrates (NO_3^-) are an important source of nitrogen (N) for plants. When nitrogen fertilizers are used to enrich soils, nitrates could also be carried by rain, irrigation and other surface waters through the soil into groundwater. Nitrate levels in beverage also can be an indicator of overall water quality.

4.4.10 Total Dissolved Solids (TDS)

Dissolved solids" are any minerals, salts, metals, cations or anions dissolved in water. Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and a few small amounts of organic matter that are dissolved in water.

4.4.11 Total Hardness as CaCO_3

The straightforward definition of water hardness is that the amount of dissolved calcium and magnesium within the water. Water is high in dissolved minerals, both calcium and magnesium. ... When water is heated, like during a home hot-water heater, solid deposits of carbonate.

4.4.12 Total alkalinity as CaCO_3

Alkalinity may be a water characteristic that quantifies the capacity of water to neutralize acids, namely, accepts hydrogen ions H^+ . Naturally occurred alkalinity is within the range from 400 to 500 mg/L. As an example, calculate alkalinity if 1 L of water contains 0.35 g of HCO_3^- and 0.12 g of CO_3^{2-} carbonate ions.

4.5 WATER QUALITY STANDARDS

The following table 4.5 gives the drinking water standards given by WHO and BIS for different water quality parameters.

Table 4.5: Drinking water standards

PARAMETERS	UNITS	ACCEPTABLE LIMIT	PERMISSIBLE LIMIT IN ABSENCE OF ALTERNATE
E.C	uS/cm	Below 400	Should not exceed 400
pH	-	6.5 TO 8.5	No relaxation
Calcium	Mg/l	Max.75	Max.200
Magnesium	Mg/l	Max.30	Max.100
Sodium	Mg/l	Max.200	Max.400
Potassium	Mg/l	Max.3000	Max.4000
Bicarbonate	Mg/l	Max.500	Max.800
Sulphate	Mg/l	Max.200	Max.300
Chloride	Mg/l	Max.250	Max.1000
Nitrate	Mg/l	Max.45	Max.50
TDS	Mg/l	Max.400	Max.900
TH	Mg/l	Max.200	Max.600
Total alkalinity	Mg/l	Max.20	Max.250

4.6 WATER QUALITY INDEX:

The weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. The method has been widely by various scientists and the calculation of WQI was made by using the following equation:

$$WQI = \frac{\sum Q_i W_i}{\sum W_i}$$

The quality rating scale (q_i) for each parameter is calculated by using this expression:

$$Q_i = 100 \left[\frac{V_i - V_o}{S_i - V_o} \right]$$

Where,

- V_i is the estimated concentration of parameter in the analyse water
- V_o is the ideal value of this parameter in pure water
- $V_o = 0$ (except pH=7.0 and DO=14.6mg/l)
- S_i is recommended standard value of the parameter

unit weight (W_i) for each water quality parameter is calculated by using the following formula:

$$W_i = K / S_i$$

Where,

K =Proportionality constant and can also be calculated by using the following equation

$$K = 1 / \sum (1/S_i)$$

Table 4.6: water quality index for sample 1

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	1940	300	300	0.0135	646.67	0.877
2.	pH	6.6	6.5-8.5	7.5	0.5429	88	47.7752
3.	Calcium	86	75	75	0.05429	114.6667	6.2252
4.	Magnesium	56	30	30	0.1357	186.67	25.331119
5.	sodium	230	200	200	0.0203	115	2.3345
6.	Potassium	20	250	250	0.0162	8	0.1296
7.	Bicarbonate	336	150	150	0.027149	224	6.081376
8.	sulphate	28	150	150	0.027149	18.6667	0.50678
9.	chloride	319	250	250	0.0162	127.6	2.06712
10	Nitrate	154	45	45	0.090498	342.22	30.970
11.	TDS	1063	500	500	0.008145	212.6	1.7316
12	TH	445	300	300	0.013575	148.33	2.013625
13.	Total alkalinity	275	120	120	0.033937	229.16	7.77729
					$\Sigma Wi=0.999513$		$\Sigma Wi*Qi=133.81814$

Table 4.7: water quality index for sample 2

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	1820	300	300	606.6667	0.116472	70.65952
2.	Calcium	94	75	75	125.3333	0.048733	6.107862
3.	Magnesium	35	30	30	116.6667	0.048733	5.68551
4.	Sodium	232	200	200	116	0.060916	7.066277
5.	Potassium	21	250	250	8.4	0.04386	0.368421
6.	Bicarbonate	488	150	150	325.3333	0.02924	9.512671
7.	Sulphate	39	150	150	26	0.050195	1.305068
8.	Chloride	264	250	250	105.6	0.109649	11.57895
9.	Nitrate	49	45	45	108.8889	0.117446	12.78861
10	TDS	999	500	500	199.8	0.11501	22.97895
11.	TH	380	300	300	126.6667	0.087719	11.11111
12	Total Alkalinity	400	120	120	333.3333	0.041423	13.80767
13.	pH	6.9	6.5-8.5	7.5	20	0.130117	2.60234
					$\Sigma W_i=0.999513$		$\Sigma W_i*Q_i=175.5729$

Table 4.8: water quality index for sample 3

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	3320	300	300	1106.667	0.116472	128.8954
2.	Calcium	168	75	75	224	0.048733	10.91618
3.	Magnesium	153	30	30	510	0.048733	24.8538
4.	Sodium	258	200	200	129	0.060916	7.858187
5.	Potassium	38	250	250	15.2	0.04386	0.666667
6.	Bicarbonate	153	150	150	102	0.02924	2.982456
7.	Sulphate	381	150	150	254	0.050195	12.74951
8.	Chloride	652	250	250	260.8	0.109649	28.59649
9.	Nitrate	145	45	45	322.2222	0.117446	37.84384
10	TDS	1873	500	500	374.6	0.11501	43.08265
11.	TH	1050	300	300	350	0.087719	30.70175
12	Total Alkalinity	125	120	120	104.1667	0.041423	4.314896
13.	pH	6.6	6.5-8.5	7.5	80	0.130117	10.40936
					$\Sigma W_i=0.999513$		$\Sigma W_i*Q_i=343.8712$

Table 4.9: water quality index for sample 4

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	2580	300	300	860	0.116472	100.1657
2.	Calcium	132	75	75	176	0.048733	8.576998
3.	Magnesium	51	30	30	170	0.048733	8.2846
4.	Sodium	297	200	200	148.5	0.060916	9.046053
5.	Potassium	20	250	250	8	0.04386	0.350877
6.	Bicarbonate	610	150	150	406.6667	0.02924	11.89084
7.	Sulphate	52	150	150	34.66667	0.050195	1.740091
8.	Chloride	411	250	250	164.4	0.109649	18.02632
9.	Nitrate	152	45	45	337.7778	0.117446	39.67078
10	TDS	142.1	500	500	28.42	0.11501	3.268577
11.	TH	540	300	300	180	0.087719	15.78947
12	Total Alkalinity	500	120	120	416.6667	0.041423	17.25958
13.	pH	6.8	6.5-8.5	7.5	40	0.130117	5.20468
					$\Sigma Wi=0.999513$		$\Sigma Wi*Qi=239.2746$

Table 4.10: water quality index for sample 5

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	2080	300	300	693.3333	0.116472	80.75374
2.	Calcium	92	75	75	122.6667	0.048733	5.977908
3.	Magnesium	90	30	30	300	0.048733	14.61988
4.	Sodium	191	200	200	95.5	0.060916	5.817495
5.	Potassium	20	250	250	8	0.04386	0.350877
6.	Bicarbonate	427	150	150	284.6667	0.02924	8.323587
7.	Sulphate	29	150	150	19.33333	0.050195	0.970435
8.	Chloride	362	250	250	144.8	0.109649	15.87719
9.	Nitrate	144	45	45	320	0.117446	37.58285
10	TDS	1142	500	500	228.4	0.11501	26.26823
11.	TH	600	300	300	200	0.087719	17.54386
12	Total Alkalinity	350	120	120	291.6667	0.041423	12.08171
13.	pH	7.1	6.5-8.5	7.5	20	0.130117	2.60234
					$\Sigma Wi=0.999513$		$\Sigma Wi*Qi=228.7701$

Table 4.11: water quality index for sample 6

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	1980	300	300	660	0.116472	76.87135
2.	Calcium	97	75	75	129.3333	0.048733	6.302794
3.	Magnesium	57	30	30	190	0.048733	9.259259
4.	Sodium	176	200	200	88	0.060916	5.360624
5.	Potassium	27	250	250	10.8	0.04386	0.473684
6.	Bicarbonate	552	150	150	368	0.02924	10.76023
7.	Sulphate	46	150	150	30.66667	0.050195	1.539311
8.	Chloride	399	250	250	159.6	0.109649	17.5
9.	Nitrate	112	45	45	248.8889	0.117446	29.2311
10	TDS	965	500	500	193	0.11501	22.19688
11.	TH	780	300	300	260	0.087719	22.80702
12	Total Alkalinity	187	120	120	155.8333	0.041423	6.455084
13.	pH	7.3	6.5-8.5	7.5	60	0.130117	7.80702
					$\Sigma W_i=0.999513$		$\Sigma W_i*Q_i=216.5644$

Table 4.12: water quality index for sample 7

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	1980	300	300	660	0.116472	76.87135
2.	Calcium	97	75	75	129.3333	0.048733	6.302794
3.	Magnesium	57	30	30	190	0.048733	9.259259
4.	Sodium	176	200	200	88	0.060916	5.360624
5.	Potassium	27	250	250	10.8	0.04386	0.473684
6.	Bicarbonate	552	150	150	368	0.02924	10.76023
7.	Sulphate	46	150	150	30.66667	0.050195	1.539311
8.	Chloride	399	250	250	159.6	0.109649	17.5
9.	Nitrate	112	45	45	248.8889	0.117446	29.2311
10	TDS	965	500	500	193	0.11501	22.19688
11.	TH	780	300	300	260	0.087719	22.80702
12	Total Alkalinity	187	120	120	155.8333	0.041423	6.455084
13.	pH	7.3	6.5-8.5	7.5	60	0.130117	7.80702
					$\Sigma W_i=0.999513$		$\Sigma W_i*Q_i=216.5644$

Table 4.13: water quality index for sample 8

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	1550	300	300	516.7	0.116472	60.17706
2.	Calcium	104	75	75	138.7	0.048733	6.757635
3.	Magnesium	49	30	30	163.3	0.048733	7.959714
4.	Sodium	127	200	200	63.5	0.060916	3.868177
5.	Potassium	31	250	250	12.4	0.04386	0.54386
6.	Bicarbonate	305	150	150	203.3	0.02924	5.945419
7.	Sulphate	37	150	150	24.67	0.050195	1.238142
8.	Chloride	280	250	250	112	0.109649	12.2807
9.	Nitrate	84	45	45	186.7	0.117446	21.92333
10	TDS	865	500	500	173	0.11501	19.89669
11.	TH	460	300	300	153.3	0.087719	13.45029
12	Total Alkalinity	250	120	120	208.3	0.041423	8.629792
13.	pH	7.5	6.5-8.5	7.5	100	0.130117	13.0117
					$\Sigma Wi=0.999513$		$\Sigma Wi*Qi=175.6825$

Table 4.14: water quality index for sample 9

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	1290	300	300	430	0.116472	50.08285
2.	Calcium	88	75	75	117.3333	0.048733	5.717999
3.	Magnesium	44	30	30	146.6667	0.048733	7.147498
4.	Sodium	113	200	200	56.5	0.060916	3.441764
5.	Potassium	0	250	250	0	0.04386	0
6.	Bicarbonate	281	150	150	187.3333	0.02924	5.477583
7.	Sulphate	61	150	150	40.66667	0.050195	2.041261
8.	Chloride	252	250	250	100.8	0.109649	11.05263
9.	Nitrate	0	45	45	0	0.117446	0
10	TDS	699	500	500	139.8	0.11501	16.07836
11.	TH	400	300	300	133.3333	0.087719	11.69591
12	Total Alkalinity	230	120	120	191.6667	0.041423	7.939409
13.	pH	7.1	6.5-8.5	7.5	20	0.130117	2.60234
					$\Sigma Wi=0.999513$		$\Sigma Wi*Qi=123.2776$

Table 4.15: water quality index for sample 10

SI.NO	PARAMETER	OBSERVED VALUE	STANDARD VALUE	SI	WI	QI	WI*QI
1	E.C	3290	300	300	1096.667	0.116472	127.7307
2.	Calcium	224	75	75	298.6667	0.048733	14.55491
3.	Magnesium	146	30	30	486.6667	0.048733	23.7167
4.	Sodium	206	200	200	103	0.060916	6.274366
5.	Potassium	29	250	250	11.6	0.04386	0.508772
6.	Bicarbonate	464	150	150	309.3333	0.02924	9.044834
7.	Sulphate	52	150	150	34.66667	0.050195	1.740091
8.	Chloride	787	250	250	314.8	0.109649	34.51754
9.	Nitrate	91	45	45	202.2222	0.117446	23.75027
10	TDS	1767	500	500	353.4	0.11501	40.64444
11.	TH	1160	300	300	386.6667	0.087719	33.91813
12	Total Alkalinity	380	120	120	316.6667	0.041423	13.11728
13.	pH	7.3	6.5-8.5	7.5	60	0.130117	7.80702
					$\Sigma W_i=0.999513$		$\Sigma W_i*Q_i=337.325$

4.7 SPATIAL VARIATION OF WATER QUALITY PARAMETER

4.7.1 Spatial variation of electrical conductivity

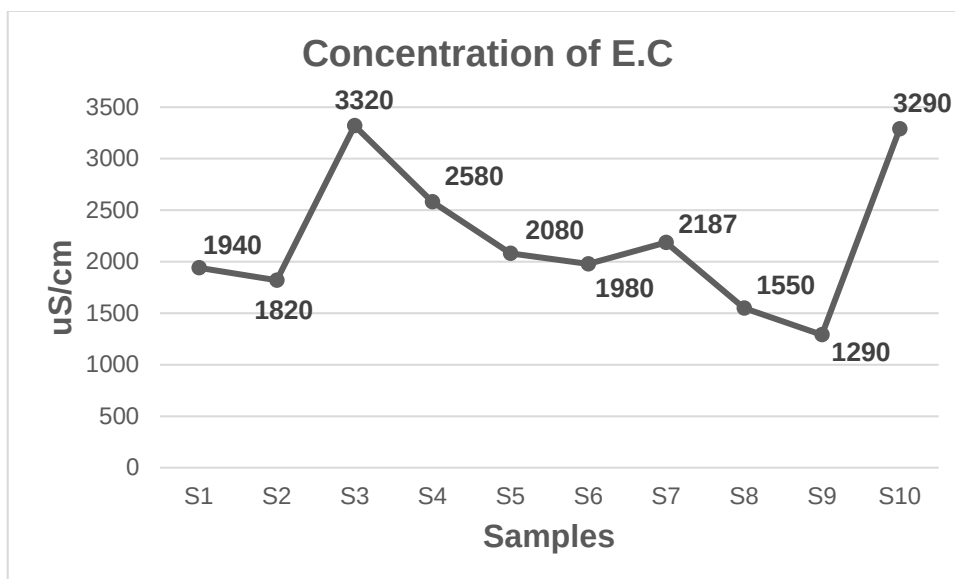


Fig: 4.7 graphs for Spatial variation of electrical conductivity

In this fig 4.7, it shows the spatial variation of electrical conductivity within the study area. Sample 3 shows a better concentration of electrical conductivity and sample 2 and sample 9 lower concentration of electrical conductivity value. . The permissible limit of electrical conductivity is 750mg/l. Increase the content of electrical conductivity within the water may cause ill effects.

4.7.2 Spatial variation of pH levels

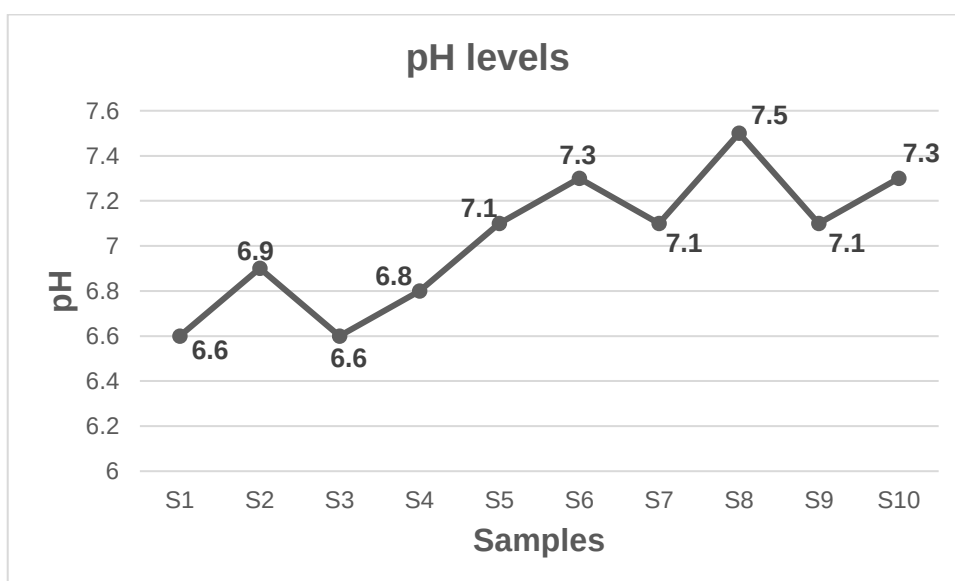


Fig: 4.8_Graph for Spatial variation of pH levels

In this fig 4.8, it shows the spatial variation of ph within the study area. Sample 8 and sample 10 shows a better concentration of ph and sample 1 may be a lower concentration value of ph. The permissible limit of ph is 6.5 to 7.5mg/l. Increase the content of ph within the water may cause ill effects.

4.7.3 Spatial Variation of calcium

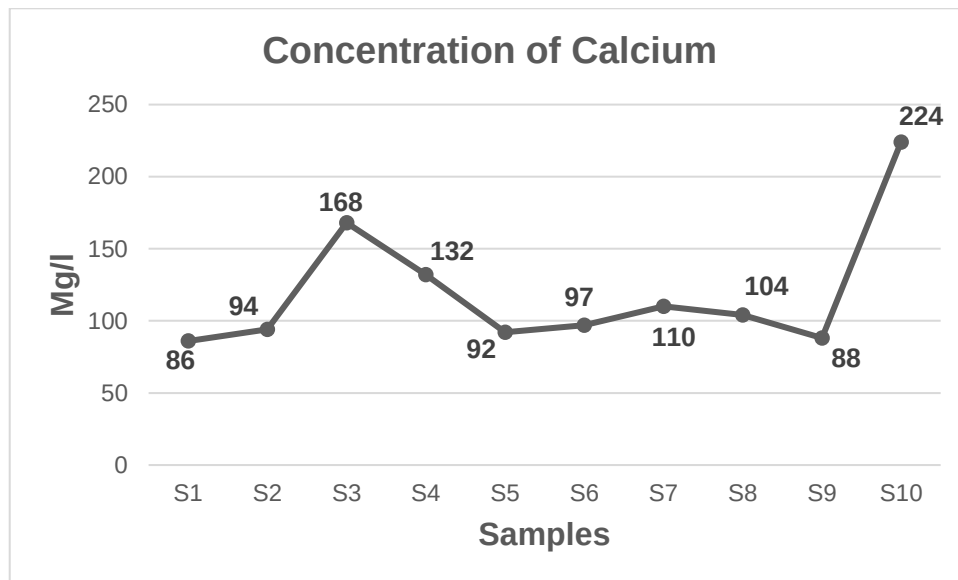


Fig: 4.9 graphs for Spatial variation of calcium

In this fig 4.9, it shows the spatial variation of calcium within the study area. Sample 3 Sample 4, and sample 10 shows a better concentration of calcium and sample 9 lower concentration of calcium value. . The permissible limit of calcium is 75mg/l. Increase the content of calcium within the water may cause ill effects.

4.7.4 Spatial variation of magnesium

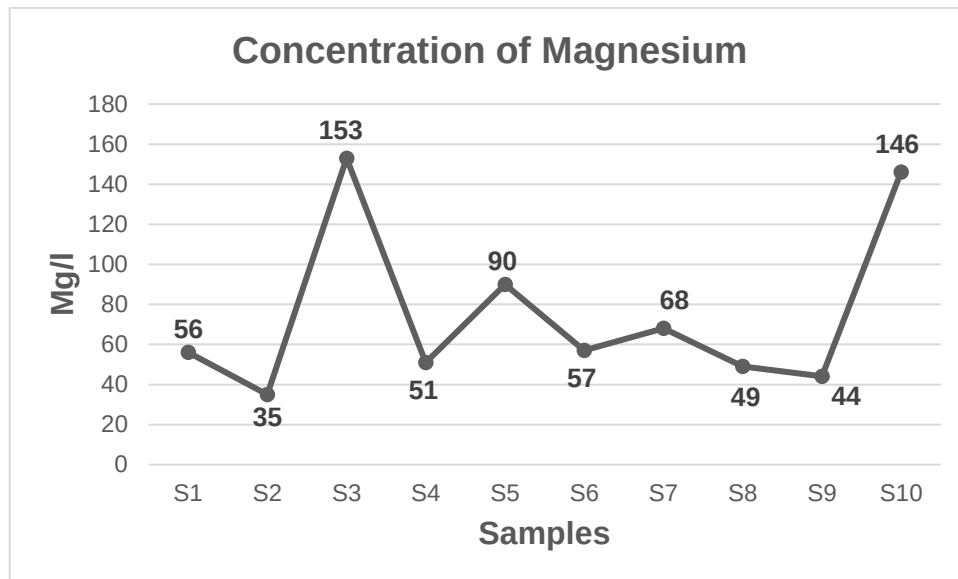


Fig: 4.10 graph for Spatial variation of magnesium

In this fig 4.10, it shows the spatial variation of magnesium within the study area. Sample 3 and sample 10 shows a better concentration of magnesium and sample 9 and sample 2 may be a lower concentration value of magnesium. The permissible limit of magnesium is 30mg/l. Increase the content of magnesium within the water may cause ill effects

4.7.5 Spatial variation of sodium

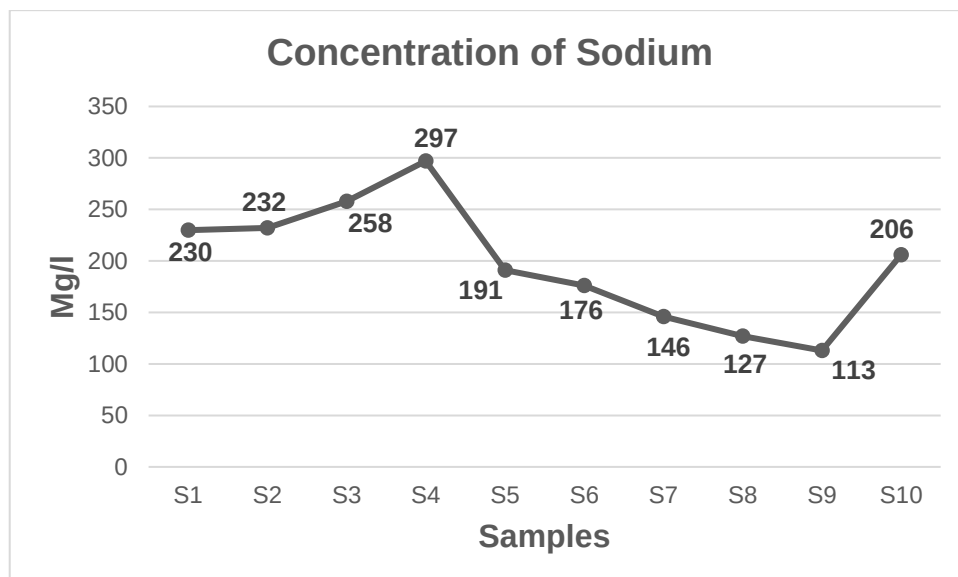


Fig: 4.11 graph for Spatial variation of sodium

In this fig 4.11, it shows the spatial variation of sodium within the study area. Sample 1, sample 4 and sample 10 shows a better concentration of sodium and sample 9 may be a lower concentration value

of sodium. The permissible limit of sodium is 200mg/l. Increase the content of sodium within the water may cause ill effects.

4.7.6 Spatial variation of potassium

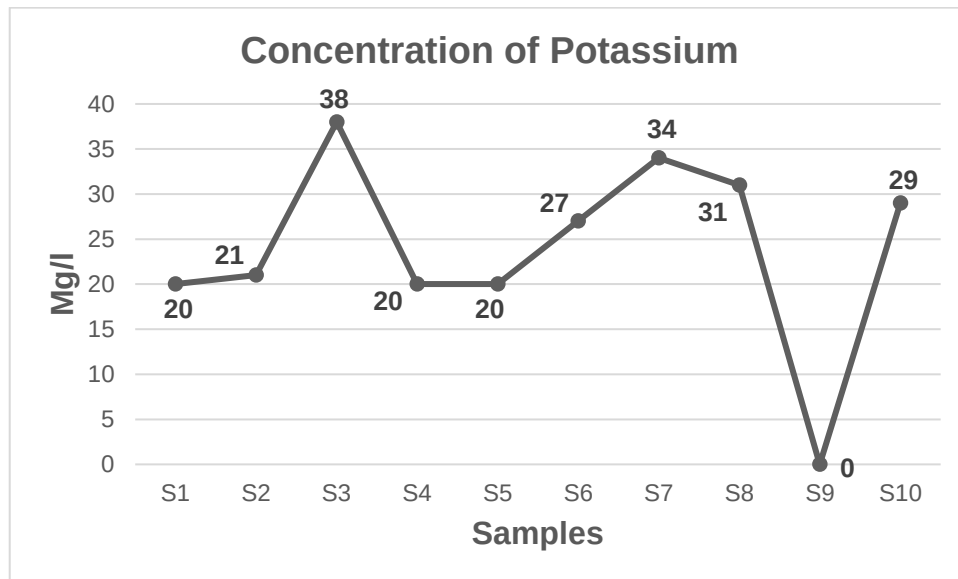


Fig: 4.12 graph for Spatial variation of potassium

In this fig 4.12, it shows the spatial variation of potassium within the study area. Sample 3 shows a better concentration of potassium and sample 9 may be a lower concentration value of potassium. The permissible limit of potassium is 100mg/l. a rise within the content of potassium within the water may cause ill effects.

4.7.7 Spatial variation of bicarbonates

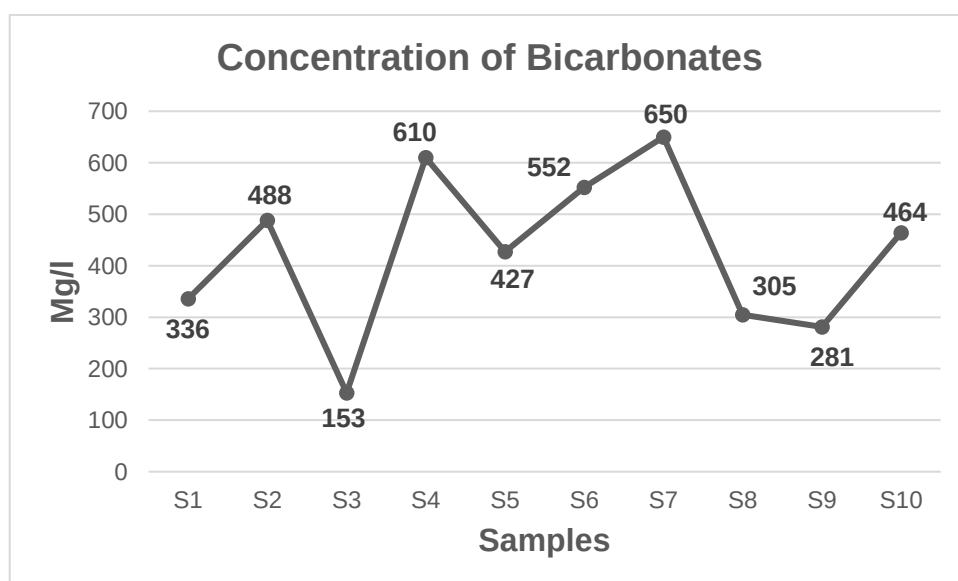


Fig: 4.13 graph for Spatial variation of bicarbonates

This Fig 4.13 shows the spatial variation of bicarbonate within the study area. Sample 7 shows a better concentration of bicarbonate and sample 3 lower concentration of bicarbonate value. . The permissible limit of bicarbonate is 200mg/l. Increase the content of bicarbonate within the water may cause ill effects.

4.7.8 Spatial variation of sulphate

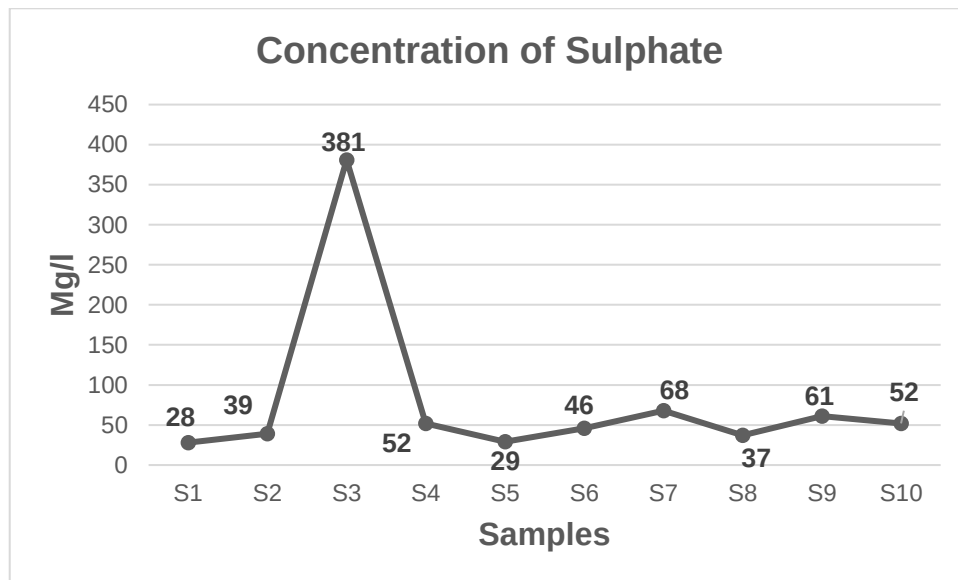


Fig: 4.14 graph for Spatial variation of sulphate

In this fig 4.14, it shows the spatial variation of sulphates within the study area. Sample 3, shows a better concentration of sulphate and sample 1 may be a lower concentration value of sulphate. The permissible limit of sulphate is 250mg/l. Increase the content of sulphate within the water may cause ill effects

4.7.9 Spatial Variation of chloride

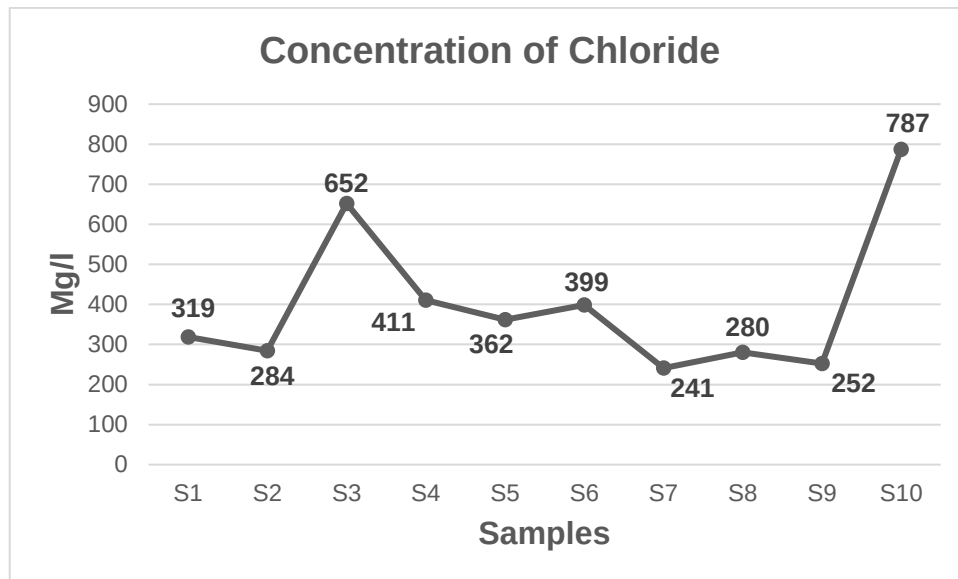


Fig: 4.15 graph for Spatial variation of chloride

In this fig 4.15, it shows the spatial variation of chloride within the study area. Sample 3, sample 10 shows a better concentration of chloride and sample 2 lower concentration of chloride value. . The permissible limit of chloride is 250mg/l. Increase the content of chloride within the water may cause ill effects.

4.7.10 Spatial variation of nitrate

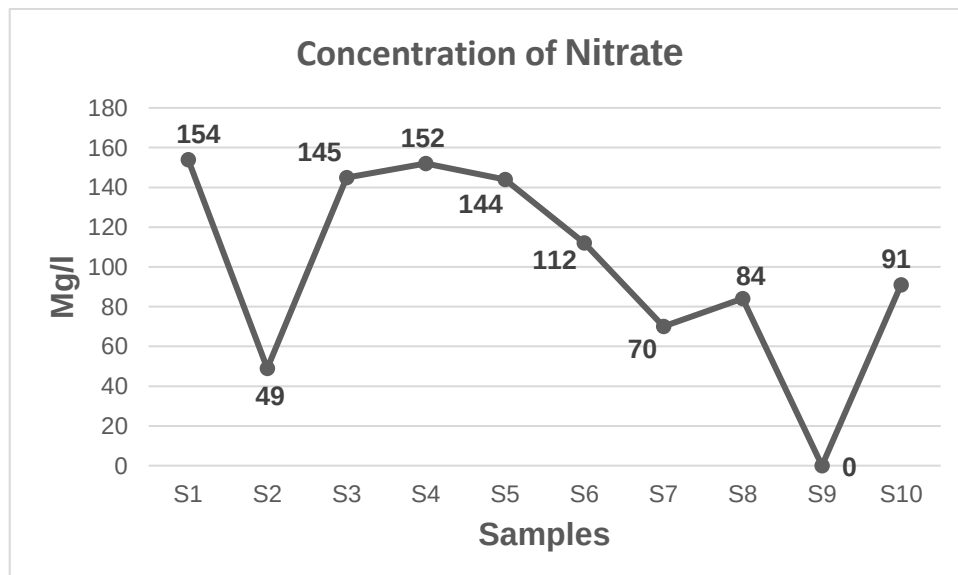


Fig: 4.16 graph for Spatial variation of nitrate

In this fig 4.16, it shows the spatial variation of nitrate within the study area. Sample 1 shows a better concentration of nitrate and sample 2, sample 7, sample 9 and is lower concentration. The permissible limit of

nitrate is 10mg/l. a rise within the content of nitrate within the water may cause ill effects.

4.7.11 Spatial variation of total dissolved solids

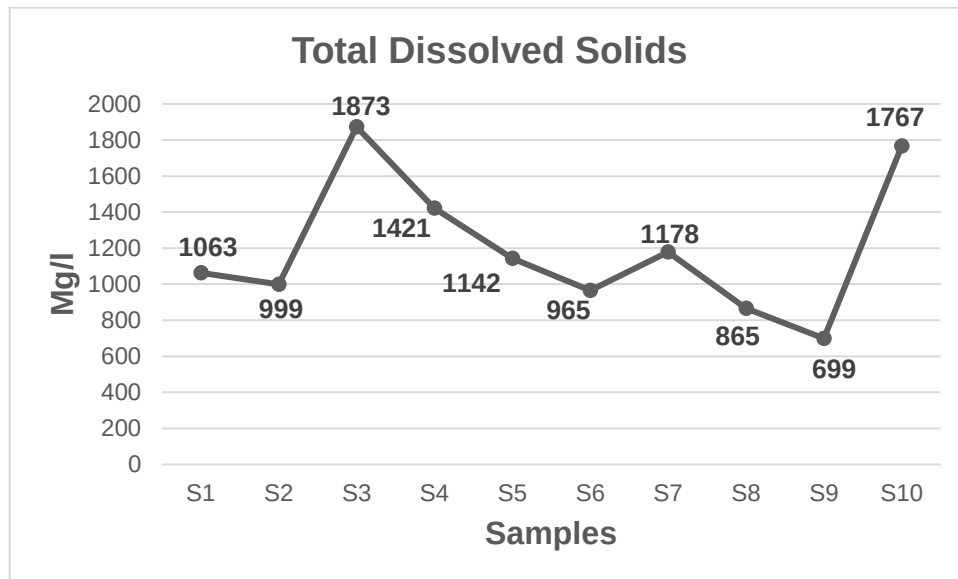


Fig:4.17 graph for Spatial variation of total dissolved solids

In this fig 4.17, it shows the spatial variation of TDS within the study area. Sample 10 shows a better concentration of TDS and sample 8 and sample 9 may be a lower concentration value of TDS. The permissible limit of TDS is 500mg/l. a rise within the content of TDS within the water may cause ill effects.

4.7.12 Spatial variation of total hardness

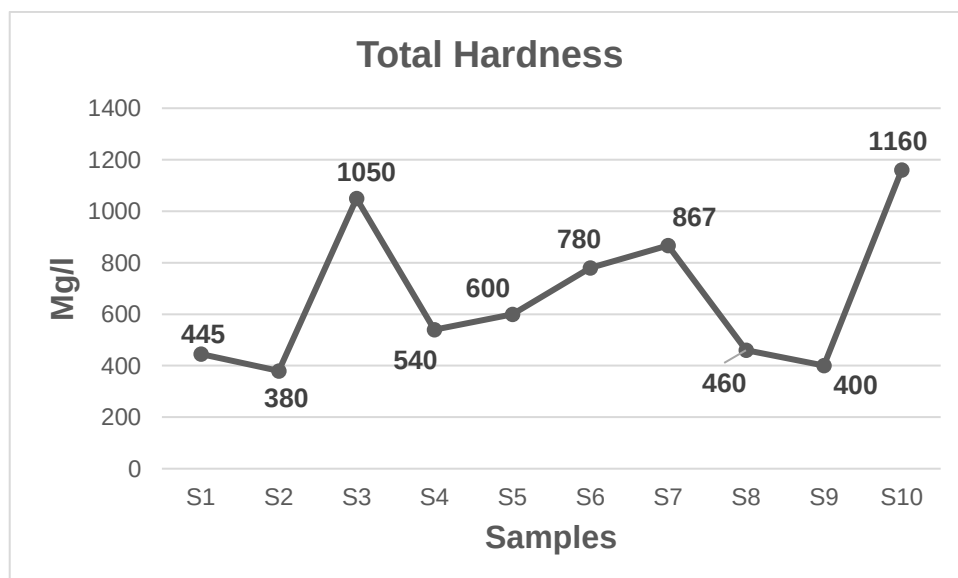


Fig: 4.18 graph for Spatial variation of total hardness

In this fig 4.18, it shows the spatial variation of Hardness caused by compounds of calcium and magnesium, and by a spread of other metals. General guidelines for classification of waters are 0 to 60 mg/L (milligrams per litre) as carbonate is assessed as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and quite 180 mg/L as very hard.

4.7.13 Spatial Variation of Total Alkalinity

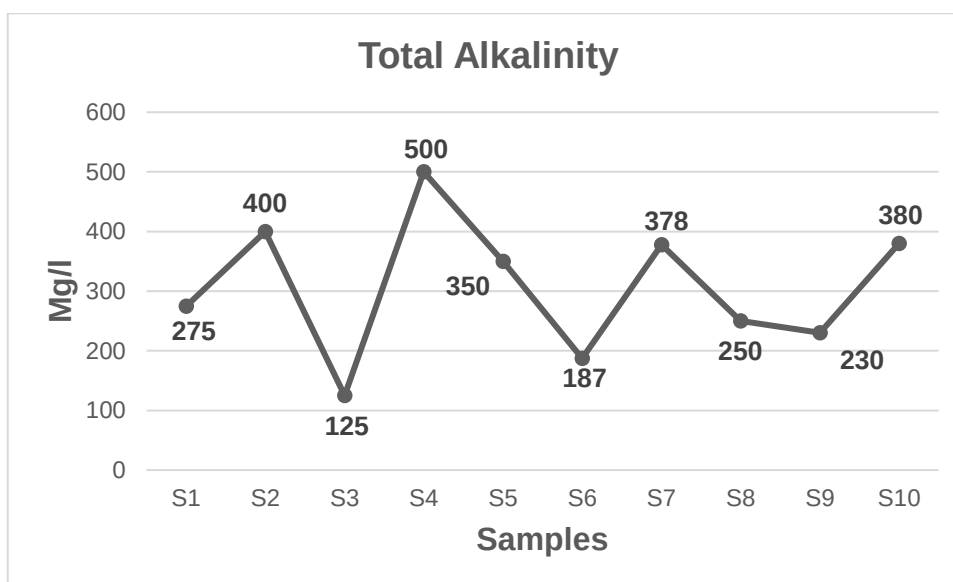


Fig: 4.19 graph for Spatial variation of Alkalinity

Alkalinity may be a measure of the acid-neutralizing capacity of water. it's an aggregate measure of the sum of all titratable bases within the sample. during this fig 4.19, it shows the spatial variation of Alkalinity caused by carbonate ($\text{CO}_3^{=}$), bicarbonate (HCO_3^{-}), and hydroxyl (OH^{-}) anions. However, borates, phosphates, silicates, and other bases also contribute to alkalinity if present. This property is vital when determining the suitability of water for drinking. Alkalinity is typically reported as equivalents of carbonate (CaCO_3).

CHAPTER- 5

RESULT AND DISCUSSION

5.1 RESULT

The pH of all the groundwater samples was almost neutral, the range is 6.6 to 7.5. The EC may be a valuable indicator of the quantity of matter dissolved in water. The EC of water samples varied from 1290 us/cm to 3320 us/cm. EC of water may be a direct function of its total dissolved solids. Total dissolved solids range from 699 mg/L to 1873 mg/L. Hardness is a crucial factor for domestic also as industrial purposes. Total hardness varied from 400 mg/L to 1160 mg/L.

Alkalinity may be a total measure of substance in water that has the acid-neutralizing ability. Carbonates and hydroxide compounds in rocks are the most sources of natural alkalinity. the entire alkalinity value ranges from 380 mg/L to 1160 mg/L. An more than Cl^- in water is typically taken as an index of pollution and thought of as tracers for groundwater contamination. Chloride concentration was found within the range of 242 mg/L to 787 mg/L. The concentration of sulphate ions varied from 28 mg/L to 381 mg/L. The high concentration of sulphate features a laxative effect which is enhanced when sulphate is consumed with magnesium.

The cations of Ca^{2+} and Mg^{2+} are directly connected to the pH value. the upper the Ca^{2+} content, the less the negative impact of Na^+ and Cl^- . The concentration of Ca^{2+} varied from 86 mg/L to 224 mg/L. Mg^{2+} ranged from 35 mg/L to 153 mg/L. More Magnesium present within the water will adversely affect the soil quality converting it to alkaline and reduce crop yield. Potassium value ranges from 0 to 38 mg/L.

5.2 COMPARISION WITH STANDARDS

The number of samples exceeding the allowable limits set by WHO is given in table 4.2. The pH and EC value of all the samples are within the permissible limit suggested by WHO. The TDS value of sample 2 and three three exceeding the permissible limits. High TDS levels end in excessive staining of water pipes. The calcium and chloride values of all the samples are exceeding the permissible limit suggested by WHO and BIS. The

magnesium values of samples 1,3,4,5 and 10 are permissible limit suggested by WHO. The sulphate values of all the samples are within the permissible limit except sample 3. The sodium values of samples 1,2,3,4 and 10 are exceeding the limit suggested by WHO. the entire hardness values of samples 3,10 are exceeding the permissible limit suggested by BIS.

Table 5.1: Comparison of WQI with water quality status

S.No	Water Quality Index	Water quality status
1	<50	Excellent water quality
2	50-99.99	Goodwater quality
3	100-199.99	Poor water Quality
4	200-299.99	Very poor water quality
5	≥300	Unsuitable for drinking and irrigation

5.3 COMPARISION OF WATER QUALITY INDEX OF SAMPLES:

For computing WQI values, every 10 values are assigned a weight and water quality rating. of these values are consistent with the rules of the WHO standard. Samples denoted as S1, S2, S3, S4, S5, S6, S7, S8, S9, and S10. This sample water has collected either bore well or open well. All the ten samples were tested for the physic-chemical analysis as 13 parameters. From the table, the values are compared with the permissible limit and finalized the result on whether the water is sweet quality or poor quality. From this result, none of the samples is within the permissible limit all the ten samples is exceeding the limit. Groundwater has been contaminated tons and it's not suitable for drinking purpose. The water within the Thiruvallur area is of poor quality and can't be used for further purpose.

Table 5.2 Comparison of water quality index of samples

<u>S.No</u>	<u>Sample</u>	<u>WQI</u>	<u>Water quality status</u>
1	Sample 1	133.88	Poor water
2	Sample 2	175.65	Poor water
3	Sample 3	344.03	Unsuitable for drinking
4	Sample 4	239.39	Very poor water
5	Sample 5	288.88	Very poor water
6	Sample 6	216.66	Very poor water
7	Sample 7	220.13	Very poor water
8	Sample 8	175.76	Poor water
9	Sample 9	123.33	Poor water
10	Sample 10	337.48	Unsuitable for drinking

CHAPTER- 6

SUMMARY AND CONCLUSIONS

6.1 CONCLUSION

The analysis of the result shows that the parameters like Calcium, Total hardness, Chloride, Manganese, Total dissolved solids and Sulphate concentration of sample 4 were above the permissible limit by the Bureau of Indian Standards. The pH range of all the samples are within the permissible limit for all the samples and in most of the samples, the chloride concentration was quite the permissible limit. The test on the concentration of physicochemical parameters on the collected sample shows that the presence of a little quantity of concentration of parameters was above the detection level. albeit the concentration of most of the parameters is within the permissible limit the concentration was more the suitable levels given by the Bureau of Indian Standards. So, Necessary steps must be taken to guard against further contamination of groundwater and maintain the concentration of various parameters within the permissible limit.

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