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Review on Groundwater Quality in Surat District by Effective Quality Model and Physico - Chemical Study

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ABSTRACT

Groundwater quality in Surat, a rapidly urbanizing industrial city in Gujarat, is of critical concern due to its direct impact on public health, agriculture, and sustainable development. This study investigates the physico-chemical characteristics of groundwater across key residential, industrial, and peri-urban zones of Surat. Representative water samples were collected seasonally and analyzed for parameters including pH, electrical conductivity (EC), total dissolved solids (TDS), temperature, total hardness, acidity as well as indicators such as chloride where relevant. The results were compared against the Bureau of Indian Standards (BIS) and World Health Organization (WHO) guidelines to assess potability and suitability for irrigation. Spatial variations indicated elevated TDS and nitrate levels in areas influenced by industrial effluent discharge and intensive agricultural activity, while elevated chloride and sodium levels were notable near coastal and urban fringe zones. Hydrogeochemical facies were identified using Piper and Durov diagrams to determine the dominant water types and possible groundwater evolution processes. Pollution indices such as the Water Quality Index (WQI) helped categorize areas of concern requiring immediate intervention. The study underscores the need for integrated groundwater management strategies, regular monitoring, and policy actions to mitigate contamination sources and ensure sustainable groundwater use in Surat.

KEYWORDS: *Groundwater quality, physico chemical parameters, effective quality model.*

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INTRODUCTION

Ground water is most important natural resources. The water that exists in the voids between the particles of the subsurface soil and in the cracks is groundwater. In aquifers, vast amounts of groundwater are contained. Ground water usage is about 50% of total water used. It is the primary source of water for human activities such as agriculture, industry and domestic drinking water especially in regions with limited annual precipitation (Todd, 1980). So it is important to maintain ground water quality detoriation due to anthropogenesis activities. This is a major concern now, a few days ago. The water quality research is therefore very critical for maintaining and prefecting the natural eco system. These issues restrict the use of groundwater and generate additional difficulties in meeting the rising demand for water. There are various forms of Contaminants Such as nitrate, Heavy metals and saltwater, that can be present in groundwater. (Reepal K. Patel, Dr. Sanjay Singh 2021)

Groundwater quality can be influenced directly and indirectly by microbiological processes which can transform both inorganic and organic constituents of groundwater through geochemical processes. Groundwater pollution occurs when used water is returned to the hydrological cycle. Groundwater bodies are always less accessible than surface water bodies and technically difficult to derive a real picture. It contaminates mainly due to the rapid increase in population, industrialization, mining operations, application of fertilizers in agricultural fields and other manmade activities. Industrialization is one of the most important phenomena which ignites the mechanism of development. Disposal of solid waste in open pits and depression, discharge of untreated liquid waste through open drains, and emission of toxic 2 gases into the atmosphere are a few common features prevalent in the industrial region and its vicinity. Groundwater gets contaminated in various ways such as excessive use of fertilizer in farming, seepage from effluent bearing discharged from industries, or human intervention. Once the groundwater gets contaminated, its quality cannot be restored by stopping the pollutant from the source in a short period. The occurrence, distribution and movement and composition of groundwater are intricately linked to the structure and nature of the geological formations. The distribution of water in terms of quality and quantity varies from place to place and from one geological formation to another. (Mukesh Kumar Bind, Rolee Kanchan 2020)

According to the World Health Organization, about 80 per cent of all human illnesses are caused by water. The groundwater quality cannot be rejuvenated by ceasing contamination at the source once it gets polluted.

It is essential to regularly monitor the quality of the groundwater and devise methods to protect it. The water quality indicator is a handy tool for conveying water-based information to voters and policy-makers. It, therefore, becomes an essential parameter for the monitoring and management of groundwater. WQI is defined as a measure that reflects the combined effect of various water quality parameters. WQI is calculated from the target or suitability of groundwater quality for human consumption. (Mahima et. al 2021)

THREATS TO GROUNDWATER QUALITY

Groundwater quality is increasingly deteriorating due to a combination of natural processes and human activities. As groundwater serves as a primary source of drinking and irrigation water, its contamination poses serious risks to public health, food security, and environmental sustainability.

One of the most significant threats to groundwater quality is industrial pollution. Discharge of untreated or partially treated industrial effluents introduces toxic substances such as heavy metals, chemicals, and organic pollutants into aquifers. These contaminants can persist for long periods and are difficult to remediate.

Agricultural activities also play a major role in degrading groundwater quality. Excessive use of fertilizers, pesticides, and herbicides leads to nitrate and pesticide leaching into groundwater, making water unsafe for consumption and causing health issues such as methemoglobinemia.

Domestic sewage and septic system leakage contribute pathogens, nutrients, and organic matter to groundwater, especially in densely populated areas with inadequate sanitation infrastructure. This microbial contamination can result in waterborne diseases.

In coastal regions, over-extraction of groundwater leads to saline water intrusion, increasing chloride and sodium concentrations and reducing water suitability for drinking and irrigation.

Natural geological processes cause geogenic contamination, where elements like fluoride, arsenic, iron, and manganese dissolve into groundwater through rock–water interaction. Though naturally occurring, these contaminants can reach harmful concentrations.

Additionally, urbanization and climate change affect groundwater quality by altering recharge patterns, concentrating pollutants, and reducing dilution capacity. Reduced recharge combined with high demand accelerates contamination risks.

Protecting groundwater quality requires strict pollution control, sustainable land-use practices, regular monitoring, and public awareness to ensure safe and reliable groundwater resources for future generations.

NEED FOR IMPROVING GROUNDWATER QUALITY ASSESMENT

Improving groundwater quality analysis is essential to ensure safe drinking water, protect public health, and support sustainable water resource management. As groundwater contamination is often invisible and spreads slowly, systematic and accurate analysis is the only reliable way to detect, assess, and manage water quality issues.

One of the primary needs is **early detection of contaminants** such as nitrates, heavy metals, pathogens, and industrial chemicals. Improved analysis helps identify pollution sources at an early stage, preventing long-term damage to aquifers and reducing treatment costs.

Enhanced groundwater quality analysis supports **public health protection** by ensuring compliance with national and international drinking water standards. Regular monitoring helps prevent waterborne diseases and chronic health issues caused by prolonged exposure to contaminated groundwater.

Accurate analysis is also necessary for **sustainable groundwater management**. Understanding spatial and temporal variations in water quality enables planners and policymakers to regulate groundwater extraction, control pollution sources, and protect recharge zones.

In rapidly urbanizing and industrial regions, improved analysis assists in **environmental impact assessment** and pollution control. It provides scientific evidence for implementing treatment technologies, enforcing environmental regulations, and evaluating the effectiveness of mitigation measures.

Advanced analytical methods, such as **Water Quality Index (WQI), hydrogeochemical modeling, and GIS-based mapping**, improve data interpretation and decision-making. These tools help communicate complex water quality data in a simplified and actionable manner.

Overall, strengthening groundwater quality analysis is crucial for ensuring water security, safeguarding ecosystems, and supporting long-term socio-economic development.

STUDY AREA

Surat district is in the western area of the state of Gujarat. Due to immigration from within the state and other Indian states, it is one of India's most active districts, with one of the fastest growth rates. Surat is one of the most important districts of Gujarat with rapid urban and industrial growth. 'The City Chairman Establishment, a global research organization' focusing on urban issues, ranks Surat fourth in a global survey of the fastest-growing cities. Surat is situated on the banks of the Tapi River, with the Arabian Sea to the west, between latitudes 21°06° N and 21°15° N, and longitudes 72°45° E and 72°54° E. It is 13 meters above sea level. It is a densely populated district of Gujarat state. Surat district is divided into nine groups of villages, basically we call it a taluka, i.e., Bardoli, Choryasi, Kamrej, Mahuva, Mandvi, Mangrol, Olpad, Palsana and Umarpada, it covers an area of about 4,418 sq. km. (Patel et. al 23)

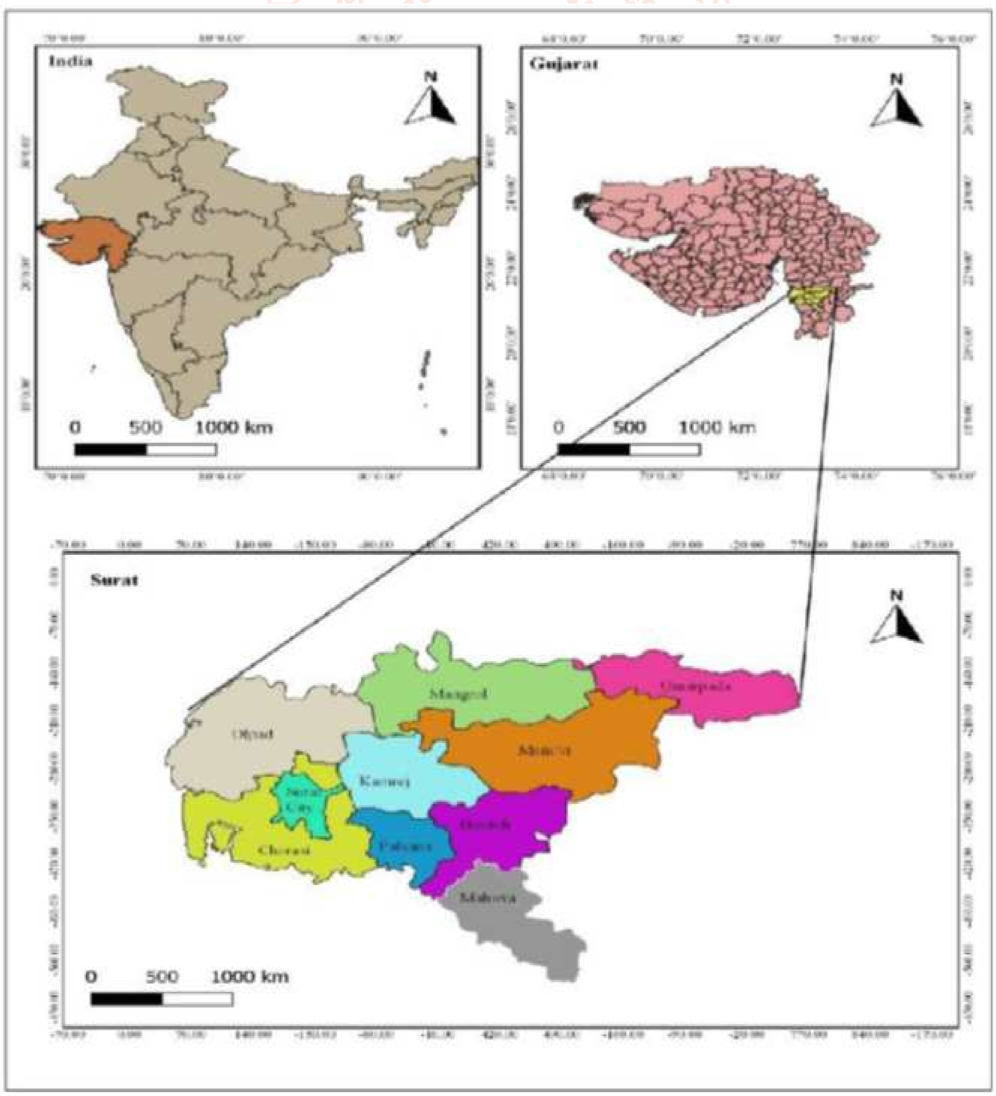

Figure 1.1 study area (Patel et.al 2023)

METHODOLOGIES USED FOR GROUNDWATER QUALITY ANALYSIS

Analysis results are used to determine the groundwater quality index to assign the suitability of groundwater for human consumption. The computation of GWQI encompasses the weightage factor of groundwater quality parameter, prescribed groundwater quality standard and analyzed concentration of respective parameter. Flexibility lies with this computation is to give the relative importance to contributing parameters of overall groundwater quality for e.g. laboratory results of groundwater quality parameters in study area indicates the overall quality which is primly affected by pH, TDS, Chlorides, Hardness. Therefore, set of such parameters are considered in the computation of GWQI of study area however, the consideration may include the different set of parameters for the other region. (Mehta et. al 2018)

SR. NO.	PAPER TITLE	YEAR	RESEARCHER	PARAMETER USED	SAMPLES
1	Quality Characterization of Groundwater using Water Quality Index in Surat city, Gujarat, India	2012	Mangukiya Rupal Bhattacharya Tanushree Chakraborty Sukalyan	pH, total hardness, calcium, magnesium, chloride, nitrate, sulphate, total dissolved solids, iron, boron, and fluorides, COD and DO	125 samples
2	Assessment of water water quality for the groundwater with respect to salt water intrusion at coastal region of Surat city, Gujarat, India.	2012	Desai B. and Desai H.	iron, total dissolved solids, hardness, fluoride, silica, chloride, COD and salinity	25 samples
3	Analysis of Groundwater Quality With Respect to Seawater Intrusion in Surat	2016	PAYAL U. ZAVERI JAYANTILAL N. PATEL	EC, TDS, chlorides, and hardness as bicarbonate (HCO3)	pre-monsoon season (May–June) for the years 2001 to 2012
4	Spatial distribution of groundwater quality with special emphasis on fluoride of Mandvi Taluka, Surat, Gujarat, India	2017	Mayuri Prajapati, Namrata Jariwala, Prasit Agnihotri	pH, Temp, EC, TH, Ca, Mg2, F-, TDS, HCO3, SO4, NO3, Cl-, N	57 samples
5	Evaluation of underground water quality of Surat city, Gujarat.	2017	Hemangi Desai, Tasneem Anandwala, H. Desai	total dissolved solids, turbidity, pH, conductivity, total hardness, calcium hardness, magnesium hardness, total alkalinity and chemical oxygen demand	11 samples
6	Evaluation of groundwater quality with special emphasis on fluoride contamination using multivariate statistical analysis in rural parts of Surat district, Gujarat	2018	Mayuri Prajapati, Namrata Jariwala Prasit Agnihotri	Total alkalinity (TH), Fluoride (F−), Nitrate (NO3−),Total dissolved solids (TDS), Chloride (Cl−), Sulfate (SO42−), Total hardness(TH), Calcium hardness and Magnesium hardness	82 samples
7	Evaluation of Water Quality Index for Ground Water of Residential Area of Surat City, Gujarat, India	2018	Desai Birva Desai Hemangi	Total Hardness, Ca, MgHardness, Copper, Zinc, Chloride, COD, pH, EC, Turbidity, TSS and TDS, Sodium and Potassium, Nitrite, Diazotization, Ammonia, Phenate, Silica, Heteropoly blue, Iron,	9 samples

				Phenol, Chloroform, Chromium, Boron, Phosphate, Fluoride	
8	Assessment of Ground Water Quality Index status in Surat City	2018	Darshan Mehta, Pradeepsinh Chauhan, Keyur Prajapati	TDS, pH, Total Hardness, Calcium, Magnesium, Chloride, Sulphate, Nitrate, Fluorides, Alkalinity	
9	Groundwater characteristics in different zones of Surat, Gujarat, India.	2019	Dharmendra V. Jariwala	pH, conductivity, turbidity, alkalinity, hardness, total dissolved solid, sulphate, chloride	117 samples
10	Investigate Groundwater Quality Parameters for Accomplishing Demand of Bhimrad of Surat City	2019	Manisha Desai Jayantilal Patel	Color, Odor, Turbidity, TDS, pH, Chloride, Hardness, and EC	7 samples
11	Impact on ground water due to textile industries in Kadodara Region, Surat, Gujarat, India	2019	Isha Shah, J. S. Sudarsan, Umang Shah, S. Ramesh, Mir Sehran	pH, Electrical Conductivity, Turbidity, Total Dissolved Solids, Turbidity, Chlorides (Cl-1)	10 samples
12	Assessing groundwater quality using geospatial technology : A CASE STUDY OF SURAT DISTRICT, GUJARAT, INDIA.	2020	Mukesh Kumar Bind Rolee Kanchan	pH, turbidity, Total Dissolved Solid (TDS), calcium, magnesium, sulphate, chloride, fluoride, nitrate, alkalinity and total hardness	582 samples
13	An assessment of groundwater quality in South-West zone of Surat city	2021	Ankit N. Chaudhari, Darshan J. Mehta Dr. Neeraj D. Sharma	Electrical Conductivity (EC), Total Dissolved Solids (TDS), Ca, Cl, F, Mg, NO3, SO4, and Total Hardness.	Groundwater quality data (2006–2015)
14	Assessment of groundwater at various places of surat district using multivariate statistical techniques	2021	Reepal K. Patel, Dr. Sanjay Singh	ph, TDS, conductivity, alkalinity, sulphate, chloride, bicarbonate, magnesium, calcium, sodium, potassium	34 Samples
15	Groundwater Quality Analysis of Surat District	2021	Mahima Jariwala, Alkin Malek, Payal Zaveri	pH, TDS, chloride, HCO3 and EC.	4 samples
16	Sub surface water quality assessment using GIS techniques in Surat-Bharuch industrial region, Gujarat, India.	2021	Somnath Saha Rolee Kanchan	pH, TDS, Calcium (Ca2+), Sodium (Na+) and Fluoride (F-)	20 samples
17	Coupled effect of seawater intrusion on groundwater quality: study of South-West zone of Surat city	2022	Ankit N. Chaudhari, Darshan J. Mehta, Neeraj D. Sharma	Co3: Carbonate, Ca: Calcium, Cl: Chlorine, EC: Electrical Conductivity, F: Fluoride, Fe: Iron, HCo3: Bicarbonate, K: Potassium, Mg: Magnesium, No3: Nitrate, Na: Sodium, SAR: Sodium, adsorption ratio, So4: Nitrate, TDS: Total Dissolved solids	Water quality data: years 2008–2018

18	Assessment of groundwater vulnerability using the GIS approach-based GOD method in Surat district of Gujarat state, India	2023	Priyank Patel, Darshan Mehta, Neeraj Sharma	groundwater confinement (G), overlaying lithology (O) and depth to water table (D)	
19	Assessment of groundwater vulnerability using the GIS approach-based GOD method in Surat district of Gujarat state, India	2023	Priyank Patel, Darshan Mehta, Neeraj Sharma	Groundwater confinement (G), overlaying lithology (O) and depth to water table (D)	
20	Hydrogeochemical investigation and groundwater quality assessment toward 'smart city planning in a coastal aquifer, India	2023	Mohd Arshad, Naseem Us Saba, Tanvi Arora, Shakeel Ahmed	pH, EC, TDS, Ca, Mg, Na, K, CO3, HCO3, Cl, SO4, NO3	26 samples

SAMPLE COLLECTION AND ANALYSIS

A total of 50 groundwater samples were collected from Surat Taluka and Surat City of Surat, Gujarat. Sampling locations were selected in such way covering residential, agricultural, and industrial areas. This helps in understanding the overall groundwater quality from different types of land use. For the assessment of groundwater quality, repeated measurements were carried out to ensure precision and accuracy, so as to obtain meaningful and reliable analysis of all types of contamination present in groundwater. The samples were collected in pre-cleaned polylab bottles of one litre capacity from borewell, openwell and hand-pumps after pumping out the stagnant water present in the casing. The groundwater from these hand-pumps is commonly used for drinking, household activities, and bathing by the local residents, thus representing important public water sources. (Mayuri et. al 2015)

Physico-Chemical Analysis

Physico-chemical analysis is a fundamental approach used to assess groundwater quality by examining its physical and chemical characteristics. This analysis includes the measurement of parameters such as pH, electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, chloride, sulphate, bicarbonate, nitrate, and fluoride. These parameters provide essential information about the mineral composition, salinity, acidity or alkalinity, and overall suitability of groundwater for drinking, irrigation, and industrial purposes. The results obtained from physico-chemical analysis are commonly compared with drinking water standards prescribed by agencies such as the Bureau of Indian Standards (BIS) and the World Health Organization (WHO). This comparison helps identify contamination levels, assess potential health risks, and understand the influence of natural geological formations and human activities on groundwater quality.

Water Quality Index (WQI)

Water quality index is one of the most effective tools to monitor the surface as well as ground water pollution and can be used efficiently in the implementation of water quality upgrading programmes. The objective of an index is to turn multifaceted water quality data into simple information that is comprehensible and useable by the public. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics15. Water quality index provide information on a rating scale from zero to hundred. Higher value of WQI indicates better quality of water and lower value shows poor water quality. The calculated WQI values are then used to classify groundwater into categories such as excellent, good, poor, very poor, or unsuitable for drinking. (Mangukiya et. al 2012)

IMPACTS OF GROUNDWATER QUALITY DETERIORATION

Deterioration of groundwater quality has serious consequences for human health, agriculture, industry, and the environment. Consumption of contaminated groundwater can lead to health problems such as dental and skeletal fluorosis due to high fluoride levels, gastrointestinal disorders from excessive salinity, and methemoglobinemia caused by high nitrate concentrations. Poor-quality groundwater also affects agricultural productivity by reducing soil fertility, damaging crops, and causing salinity-related yield losses. In industrial applications, degraded groundwater increases treatment costs, causes scaling and corrosion in equipment, and reduces operational efficiency. Additionally, long-term deterioration of groundwater quality can lead to ecological imbalance, reduced availability of safe drinking water, and increased pressure on alternative water resources, making sustainable groundwater management essential.

CONCLUSION

Groundwater quality in Surat district is influenced by a combination of natural hydrogeochemical processes and human activities such as urbanization, industrialization, and agricultural practices. Review of earlier studies indicates that parameters like fluoride, salinity, hardness, and total dissolved solids exceed permissible limits in several areas, affecting the suitability of groundwater for drinking and other uses. The application of integrated assessment approaches, including physico-chemical analysis, Water Quality Index, and statistical techniques, provides a comprehensive understanding of groundwater quality status. The findings highlight the urgent need for regular monitoring, effective groundwater management, and adoption of appropriate treatment and conservation measures to ensure the sustainable use of groundwater resources and protect public health in the Surat district.

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