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Review of Groundwater Analysis in Various Regions in Tamil Nadu, India

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ABSTRACT

This study reviews the groundwater quality level, soil quality in the modern territory, and State Industries Promotion Corporation of Tamil Nadu Limited (SIPCOT) industrial areas. The groundwater quality level is focused on the different regions named as the Residential area, Residential with Part Industry which is mostly focused in Tamil Nadu, India. For the quality checking, the different physico-substance parameters are needed to be evaluated. The novelty of the paper is to review and study the groundwater quality levels with recharge zones in various regions. This study analyses the anthropogenic activities, rock–water interactions and hydro-geochemical process in the selected zone. After that, the quality of groundwater is to be monitored along with human health impacts, potentially harmful elements (PHEs), then the identification of groundwater recharge zones also computed in different areas. The main aim of the study is described about the importance of groundwater quality and their impacts. For that reason, the Water Quality Index (WQI) is used to determine the groundwater quality and Geographic Information System (GIS) technology is used to compute the accurate results of the groundwater recharge zones. As per the WQI index, the groundwater tests are conducted and validated the results with the World Health Organizations (WHO) guidelines. As per the standard tests and norms, the groundwater quality level is analyzed and predicted their soil quality in various States & Districts in India and compared with other countries also. The results of the study are finalized the majority of the parameters in the investigation region are inside as far as possible, the WQI recommends that water is reasonable for local purposes.

1. Introduction

Groundwater is the world's leading natural resource and the core of the ecosystem. Normally, the water is supplied for drinking purpose, households, agriculture, industry, recreational activities and environmental activities. As a result, demand for water supplies has increased, according to their usages (Selvakumar et al., 2017), it is very important to determine the physical, chemical and bacterial quality of groundwater. The quality level has an important role to play in the determination of groundwater usage and domestic purposes. The groundwater has excess minerals and free of harmful elements (Sunitha and Sudharshan Reddy, 2019), which is mainly depends on its geochemical composition. In addition, the quality of groundwater is differed based on their areas like rocks, industrial areas, and so on. In this region, the groundwater is depending on physical & chemical (geochemical composition) parameters, and the interaction process between soil and water. Indeed, the major cause of pollution of groundwater is become industrial and municipal solid waste (Selvakumar et al., 2017). Many researchers have studied the quality of groundwater and sources of pollution affected by industrial and natural treatment on a global scale (Selvakumar et al., 2017). The principles of the chemical characteristics of groundwater and the effects of human activity have been fully demonstrated in many parts of India.

Groundwater pollution in urban environments is a major problem, particularly in industrial urban region. So, groundwater management is necessary to restore this renewable resource. Groundwater recharge depends mainly upon porosity and permeability, with direct or indirect geological structure, the structure of land, the presence of furnishings, the path, soil texture, land use and so on (Das and Pal, 2019). Water quality

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monitoring programs are required to raise public awareness by tackling the impacts on polluted water resources on current and future threats.

The water characteristics can be broken down into three categories: physics, biology and chemistry. The water monitoring program (Abijith et al., 2020) uses these features. The advantage of RS and GIS is works based on that the combination of main data set and the auxiliary data set (Etikala et al., 2019).

Traditionally, India is a leading country in agriculture, with groundwater being is one of the most significant sources of irrigation. Nearly 50 – 80% of water is used for irrigation purpose in India which is controlled by groundwater, and 90% of rural residents and more than half of the urban population depends on the groundwater (Kaur et al., 2019). Due to the relative importance of multivariate statistical techniques in evaluating large chemical data sets, they have proven to be beneficial (Ravikumar and Somashekar, 2017; Gopinath et al., 2018). Land subsidence in cities is a risk that can be addressed by tapping into groundwater resources outside cities. The poor water quality is main issue in groundwater (Virupaksha and Lokesh, 2021). Groundwater mapping is away from pollutants or poor natural chemistry. Improve the understanding level of groundwater mapping and modelling.

The biochemical effects on the human body with acute and chronic health issues such as asthma, renal failure, bone fragility, intellectual disability, heart disease, and respiratory problems were studied, and it was discovered that it might cause cancer in humans in later stages. The Mn, Cu, Cd, Cr, Pb, Fe, and Zn are among the potentially hazardous elements (PHEs) assessed in ground water samples. Hemochromatosis occurs when the human body absorbs too much iron, and it raises the risk of arthritis, cancer, liver disorders, diabetes, and heart failure in later stages. The effects of PHEs and associated health hazards on humans have been researched using health consequences such as chronic daily intake by ingestion, cutaneous contact, hazardous quotient (HQ), and hazardous index (HI).

Therefore, in this paper, the Water Quality Index (WQI) and GIS technique are employed to calculate the different classes of water, controlled water quality and probability to determine the physicochemical parameters such as potential of hydrogen (pH), total dissolved solids (TDS) and electrical conductivity (EC) by Hanna portable meters, while total hardness (TH), alkalinity and bicarbonates. Furthermore, Analysed the ions concentration in groundwater around in Tamil Nadu, India by using ion chromatography (IC).

Here, the located SIPCOT areas in India is focused and analyzed their groundwater quality. The groundwater affecting parameters, protection of groundwater and enhancement of the soil quality is analyzed in various regions. The rest of the paper is followed as, section 3 describes that groundwater quality measurements and methodology. Before that, the scope of the study is mentioned in the section 2. In the section 4 describes about the results and discussions of the various state and districts of India. Finally, the summary of the study is mentioned in the section 5.

2. Problems in Study Area

Here, the factors of affecting groundwater quality are described and which is mainly classified as three sources like natural sources, waste disposal activities, and agricultural management practices. The waste disposal and improper farming practices in the industrial zone of SIPCOT can deteriorate groundwater. For domestic purposes, everyone uses groundwater. Groundwater is being used by agricultural communities to farm their own land. But the situation today is totally different. The use of groundwater is obsolete in many parts of India. Therefore, the water quality monitoring is necessary in India and other countries also. In this manner, checking of water quality is significant in each are every state of India.

2.1 Problem Statement

In recent years, there has been an increased awareness of the problems of groundwater pollution. Reliable predictions of pollutant movement can quantitatively describe the physical and chemical processes that control quality groundwater. Pollution of groundwater can result in poor drinking water quality, loss of water supply, degraded surface water systems, high clean-up costs, and high costs for alternative water supplies, and/or potential human health problems. Groundwater potential pollutants, quality of water consumption, and human health impacts are discussed below.

2.1.1 Potential Pollutants

One of the most serious environmental concerns that groundwater faces is pollution. Groundwater pollution occurs when dangerous compounds enter the soil from a variety of sources. When it rains, water washes over the ground's components and transports them down into aquifers below, similar to how hot water washes over a coffee filter. Fertilizers, pesticides, and herbicides soaked into the ground damage groundwater. Fertilizer nitrates are especially toxic in drinking water because they've been linked to cancer, miscarriages, and birth problems. The manufacturing sector is also a major source of pollution. Many different harmful chemicals are used in the manufacture of the things we consume, and if they are not properly disposed of, they can leak into the groundwater below. Septic tanks and other underground storage tanks can leak sewage, oil, and harmful substances into the ground, just like septic tanks (Selvam et al., 2018).

2.1.2 Human Health Impacts

The human health impacts depend on the exposure dose, frequency, and nutrition of the exposed individual calculation of CDI and HQ in each metal implies that water is unsafe for drinking and human consumption. Furthermore, analysed the cations and anions PHEs measurement with the help of atomic absorption spectrophotometer and ion chromatograph, respectively (Mishra et al., 2018). Anthropogenic activities and rock–water interactions are the major factors controlling groundwater quality, along with silicate weathering and evaporation. Noncarcinogenic human health risk evaluated from high nitrate and fluoride in drinking water for children, men, and women points to the fact, which is exceeding the allowable limit to human health (Singh and Kumar, 2017).

This study analyses the various states of India, especially focused on the state of Tamil Nadu and their districts also. In the further section, the importance of the review paper is analysed.

2.2 Necessity for the Review Paper

Recently, the groundwater level is decreased due to various reasons while the shortage of water resources in one day is rapidly increasing. In addition, groundwater is also polluted due to various man-made human activities. This will have various adverse effects on humans, animals and plants. Therefore, it is necessary to monitor the water quality and recharge the groundwater zone.

2.3 Aims of the Paper

The review paper is utilized to examine the objective points beneath.

1. Analyze the groundwater region.
2. Identify the groundwater recharge zones.
3. Check the water quality level as per the WQI.
4. Use the GIS method for groundwater analysis.

3. Analysis of Groundwater Quality in Various Study Area

This paper is analyzed and reviewed the various study area in India and Other countries. In India, which is mainly focused on TamilNadu and the cities are Chennai, Coimbatore, Tirupur, Dindugal, Erode, Salem, Karur, Nilgiri, Thoothukudi, Trichy, Vellore, Nagercoil, and Manavallakurichi. Under the India, Andra Pradesh, Uttra Pradesh, Jharkhand, Maharasatra, West Bengal and Kerala states are also focused and analyzed. In the other countries, Jordan, Brazil, and china are analyzed and reviewed in this work. The study is focused based on the SIPCOT areas, residential with part industry and coastal area for determining the groundwater levels. The groundwater quality parameters are examined in the third stage. The quality of the groundwater is inspected and validated here in accordance with the WHO's guidelines (according to its WQI). The usability of groundwater for drinking, residential, and irrigation needs is determined by the quality of groundwater. The effects of mineral constituents in water on soil and plants determine the appropriateness of ground water for irrigation (Srinivas et al., 2013; Singaraja, 2017). Based on the above factors, the water quality is determined and select whether the water is suitable for drinking, irrigation, domestic or not. The overall groundwater quality monitoring is depicted in the Fig. 1.

3.1 Ground Water Quality Measurements and Methodology

In order to analyze groundwater quality, first collect groundwater

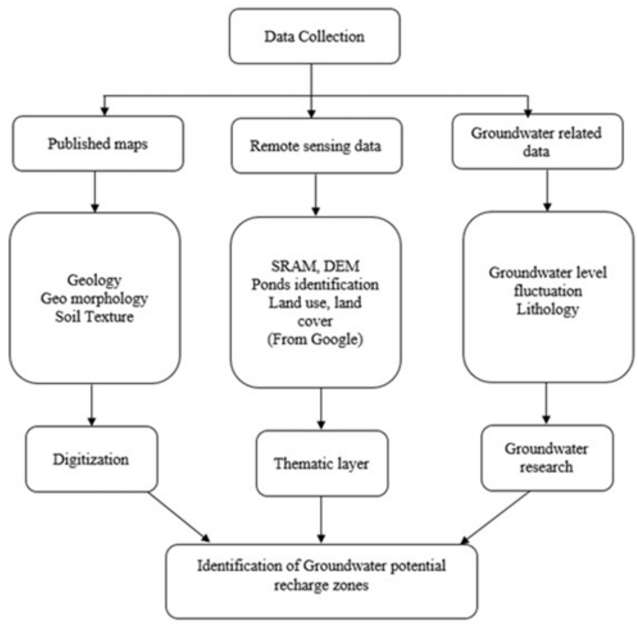

Fig. 1. Overall Process of Ground Water Quality Management

samples and tested in the Lab. For the test analysis, hydrogeochemical parameters of groundwater is analyzed like as pH, TDS, EC, chlorine, total hardness, potassium, calcium, Bicarbonate, magnesium, carbonate, sodium, and etc. The results of the study should then be compared to WHO drinking water guidelines to determine whether the groundwater is safe to drink. A geographic information system (GIS) was used to construct a lithosphere (zone) map in order to comprehend the spatial variations in hydrogeochemical parameters in the study area.

3.1.1 Geographic Information System

A Geographic Information System (GIS) is an electronic instrument that collects, stores, and transforms spatial data in real time for specific purposes and to make decisions based on the real world. Georeferenced (or) geocoded information is saved. GIS was utilised to examine the water quality and create a map in this project and mentioned in the Fig. 2. Geographic Information System (GIS) technique added with the IDW interpolation method and has proved itself as a powerful tool for evaluating and analysing spatial information of water resources. GIS technique has been used for spatial evaluation of various groundwater quality parameters (Ram et al., 2021). The selected parameters as discussed in the groundwater quality maps with the help of ArcGIS software.

The GIS strives to bring together a wide range of data acquired from a variety of sources. As a result, this is sometimes referred to as integrated analysis.

3.2 Water Quality Index

Water Quality Index (WQI) is a key metric for determining the quality of groundwater and its suitability for human consumption. The weightage system of each physio-chemical parameter indicates different influence on groundwater quality (Chakraborty et al.,

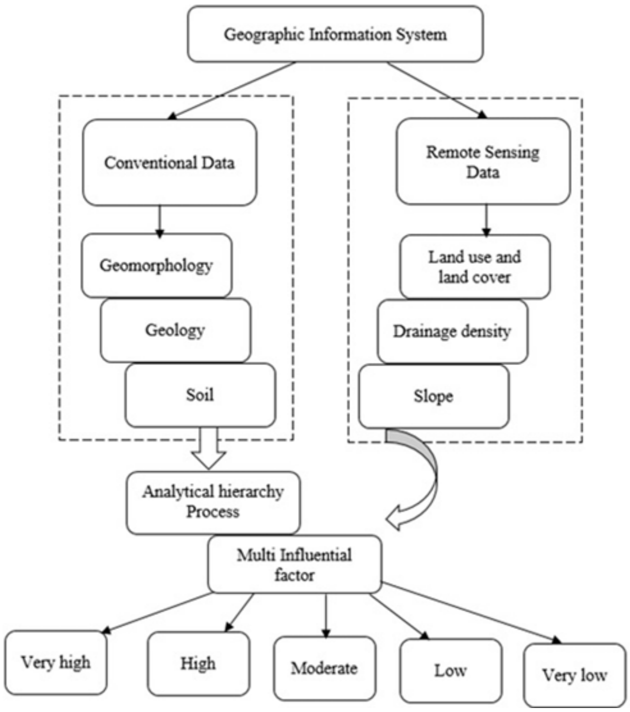

Fig. 2. GIS Analysis Process

2021). WQI is a rating system that combines the regulation of important water quality criteria to determine the overall excellence of water for human use. The WQI is classified into four groups according to its suitability for drinking water as 'very poor', 'poor', 'moderate' and 'good'.

The WHO-recommended consumption has been used to calculate the WQI. All the data of WQI were interpolated by using inverse distance weighted (IDW) method for generating WQI distribution map. IDW has been chosen for its accuracy on mapping because on this method the weight of each pixel gradually decreased from its output pixel. The values of WQI are divided into four groups and spatial distribution of WQI maps on pre-monsoon and post-monsoon.

The WQI has been determined using the drinking water quality standard recommended by the World Health Organization (WHO). The Water Quality Index has been calculated using the weighted arithmetic method. The relative weight (Wi) was calculated using the following formula:

$$W_i = \frac{W_i}{\sum_{i=1}^{n} W_i}. \tag{1}$$

From the above Eq. (1), W_i is denoted as the relative weight, w_i is mentioned as the weight of each parameter, and n represents several selected parameters and the quality rating q_i is evaluated by using the following equation:

$$q_i = \left(\frac{C_i}{S_i}\right) \times 100. \tag{2}$$

In the above Eq. (2), C_i and S_i are denoted as the amount of every physiochemical parameter in every water sample (mg/l), and the concentration of standard drinking water. To evaluate the WQI, the following parameters should be evaluated.

$$SI_i = W_i \times q_i, \tag{3}$$

$$WQI = \sum_{i-1}^{n} (SI_i), \tag{4}$$

where some different WQI can be developed for drinking water purpose and irrigation purposes.

In the analytical results, the charge-balance error for key ionic components, calculated using Microsoft Excel and the software package AQUACHEM, did not exceed 8%.

$$TH(asCaCO_3) = (Ca^{2+} + Mg^{2+})meqll \times 50 \tag{5}$$

$$SAR = Nal\sqrt{\frac{(ca+Mg)}{2}} \tag{6}$$

$$Na\% = \frac{(Na+K)}{ca+Mg+Na+K} \times 100 \tag{7}$$

$$PI = \left(\frac{Na+\sqrt{HCO_2}}{Ca+Mg+Na}\right) \times 100 \tag{8}$$

$$Magnesiumratio = \frac{(Mg)}{(Ca+Mg)} \times 100 \tag{9}$$

Based on the above analysis, the TH (Total Hardness), SAR (Sodium Adsorption Ratio), Sodium ratio, PI (Permeability Index) and Magnesium ratio are determined. In the next section, the groundwater analysis part is presented with various study areas.

4. Analysis of Results

The comparative research of groundwater quality in distinct research areas is provided and discussed in this part. The research area has been divided into three sections: SIPCOT industries, Residential with Part Crop Cultivation, and Coastal. Groundwater samples were collected from each zone for a specific time period and examined using conventional methods and techniques for physico-chemical parameters. Also presented and compared were geochemical parameters and the water quality index (WQI). The gathered and evaluated data is compared to WHO (World Health Organization) guidelines. The study's findings show that the majority of the parameters in the associated study region are within acceptable limits or are not accessible. According to the WHO, the WQI indicates whether water is acceptable for household, drinking, or agricultural use. Groundwater study of Other Countries, India Regions, and Tamil Nadu States are three separate scenarios analysed based on the analysis.

4.1 Case Studies in Other Countries

Groundwater levels in South Africa (Elumalai et al., 2017), Jordan (Tarawneh et al., 2019), and Nigeria (Ezugwu et al., 2019) are examined in this subsection. The appropriate water level for drinking and irrigation is classified based on the analysis. Elumalai et al. (2017) used the spatial interpolation method to investigate ground contamination in a Richards Bay, South Africa location. Groundwater was deemed unfit for drinking in 419 and 116 km^2, respectively. The pH, calcium, magnesium, chloride, and sulphate levels in the groundwater exceed the highest desired limit (WHO, 1993) and the maximum acceptable limits (WHO, 1993) of the examined samples, respectively. Jordan's study area was examined by Tarawneh et al. (2019). Summer, winter, and 39 bore well locations are all evaluated. However, the high salinity of groundwater makes it unsuitable for use on soils with poor drainage. However, only 72 percent of groundwater is suitable for cultivation. Ezugwu et al. (2019) investigated southeast Nigeria and found that all of the samples were excellent and safe to drink. While compared with the other countries, the most suitable drinking water quality is presented in India which is depicted in the Fig. 3. In the Table 1, some of the countries are analyzed and reviewed their drawbacks.

Agriculture consumes the most groundwater in India, which is the world's greatest user of groundwater. According to the Fifth Minor Irrigation Census, India's groundwater level dropped by 61 percent between 2007 and 2017, and 89 percent of the extracted water is used for irrigation (Etikala et al., 2019). Groundwater irrigation, despite its enormous relevance and value, is on the verge of becoming a disaster that requires immediate attention and understanding in India Vasant P. Gandhi and Namboodiri (2009). The groundwater level of India in various states and districts is examined in this study. The detailed analysis can be found in the section below.

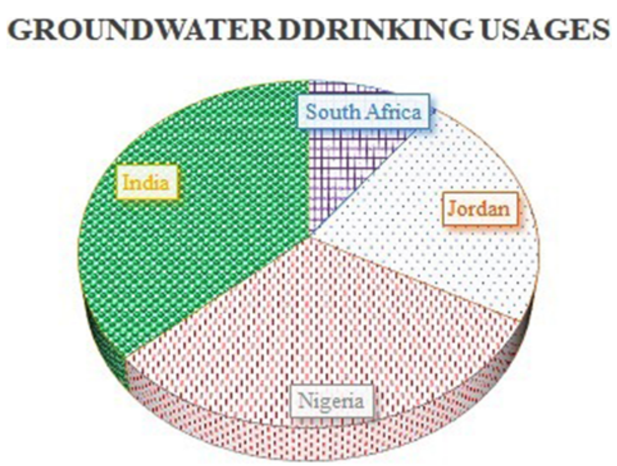

Fig. 3. Comparative Study Analysis of Various Countries-Groundwater Levels

4.2 Case Study Analysis in India at Various States

In India, the majority of research is concentrated in Andhra Pradesh (AP), West Bengal, Uttar Pradesh, Jharkhand, and Maharashtra.

4.2.1 Analysis in Andra Pradesh

This study demonstrates that the papers Etikala et al. (2019), Siddi Raju et al. (2019), Rajasekhar et al. (2019), Sunitha and Sudharshan Reddy (2019), Gupta et al. (2017), and Subba Rao et al. (2020) are analysed for groundwater quality in diverse regions of the Andra Pradesh (AP) state. Etikala et al. (2019) investigated the groundwater quality levels in Renigunta and Tirupathi in the Chittoor District which is depicted in the Fig. 5(a). They tested the 31 sampling sites in Renigunta during the pre-monsoon season of 2018 in the publication Etikala et al. (2019). According to their geochemical modelling, all wells' saturation index (SI) values for

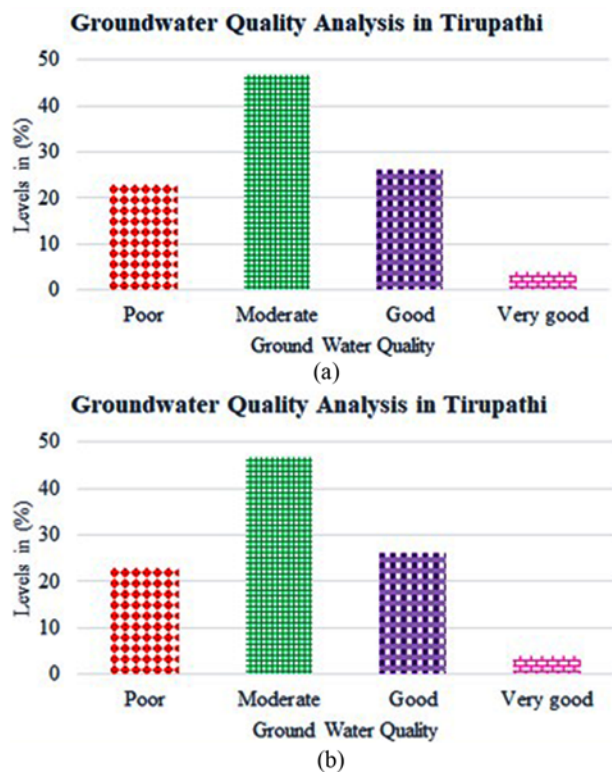

Fig. 4. Groundwater Potential Zones: (a) Levels Etikala et al. (2019), (b) Hazards Quotients Subba Rao et al. (2020)

Table 1. Comparative Study of Other Countries

Author names	Year	Study Area	Advantages	Disadvantages
Sajeev et al.	2020	Vembanad Lake, Kerala,	Surface and groundwater levels are analyzed	Pollution adversely affected water and caused by water quality deterioration
Vetrimurugan Elumalai et al.	2017	South Africa	Use of multiple techniques to avoid taking harsh decisions	It's critical to find a different source of drinking water or to cleanse the groundwater before consuming it.

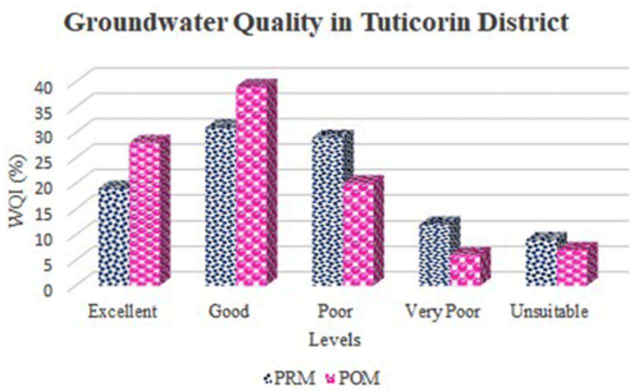

Fig. 5. Groundwater Quality Levels in Tuticorin

chloride and sulphate were under-saturated. They tested the research area in this paper Etikala et al. (2019). Other authors, such as Subba Rao et al. (2020), Sunitha and Sudharshan Reddy (2019), and Gupta et al. (2017), looked into the Guntur district and Y.S.R. District. With the analysis part, the groundwater quality is analyzed and depicted in the Fig. 4(b), and the hazards quotients are denoted as the Fig. 4(c). From this analysis, most affected persons are women and children.

Subba Rao et al. (2020) examined the 20 groundwater samples obtained from the Sattenapalle Region, Guntur district, AP, India, in their study Subba Rao et al. (2020). In men, women, and children, the non-carcinogenic risk ranges from 0.83 to 9.77, exceeding the permitted limit of one in 75 percent, 90 percent, and 100 percent of groundwater samples, respectively, depending on their body weights. Similarly, Siddi Raju et al. (2019), Rajasekhar et al. (2019), Sunitha and Sudharshan Reddy (2019) and Gupta et al. (2017) investigated several AP regions. The groundwater quality levels were specified in the comparison analysis of the investigations. The influence factors and groundwater quality levels of Andra Pradesh is tabulated in the Tables 2(a) and 2(b).

Sunitha and Sudharshan Reddy (2019) collected 30 groundwater samples from the Y.S.R District, Andhra Pradesh, and found that most of the regions were inappropriate for irrigation due to elevated MH, KI, and PS concentrations. Gupta et al. (2017) gathered 30 samples from wells in Rajam and examined and compared them to WHO and BIS criteria. The chlorinity and salinity indexes were determined to be within acceptable ranges, making them appropriate for irrigation. Subba Rao et al. (2020), Sunitha and Sudharshan Reddy (2019), Gupta et al. (2017), Siddi Raju et al. (2019), Rajasekhar et al. 2019) and Etikala et al. (2019). And the majority of the lands are unfit for drinking and irrigation. Their examination of groundwater quality is based on WHO and WQI guidelines. Table 3 shows the groundwater levels in various regions and presented their drawbacks.

Table 2. Groundwater Factors Analysis
(a) Influence Factors in Andra Pradesh

Factors	Relative weight		Assigned weight for each influential factor	
	Etikala et al. (2019)	Siddi Raju et al. (2019)	Etikala et al. (2019)	Siddi Raju et al. (2019)
Geology	4	3	22	12
Rainfall	1.5	1.5	8	6
Driange density	2	2.5	11	10
Slope	1	3	6	12
Geomorphology	2.5	3	14	12
Lineament Desnity	3	3.5	17	14
Land use/land cover	2.5	2	14	8
Soil	1.5	1.5	8	6
Total	18	20	100	80

(b) Groundwater Quality Levels in Various Regions in AP State

Various Research	Groundwater Quality levels				
	Very poor	Poor	Moderate	Good	Very good
Etikala et al. (2019)	-	23.17	46.62	26.19	4.02
Rajasekhar et al. (2019)	-	3.77	41.68	50.71	3.84
Siddi Raju etal. (2019)	36	35	35	21	7
Subba Rao et al. (2020)	25	75	-	-	-

Table 3. Comparison Analysis of Various Study Areas in Andra Pradesh

Author	Year	Study Area	Advantages	Disadvantages
Balaji Etikala et al.	2019	Renigunta area, Chittoor District, Andhra Pradesh (AP), India	Based on the Saturation index (SI) and Gibbs plot, the groundwater chemistry is analyzed. This is the easy identification.	Proper water quality monitoring is needed.
Balaji Etikala et al.	2019	Tirupati area, Chittoor District, AP, India	Groundwater potential zones can be mapped using RS, GIS, and MIF approaches (GWPZ)	Groundwater resources in different GWPZ are identified but not specify the human hazards
Siddi Raju et al.	2019	Mandavi River Basin, AP, India	It is critical to locate GWPZs where populations have experienced water shortages.	Suitable water quality monitoring is required.
Rajasekhar et al.	2019	Jilledubanderu river basin, Anantapur District, AP, India	Integrated AHP-Fuzzy, on the other hand, is simpler and more accurate, independent of user-based evaluation, due to various factors.	While executing the Fuzzy, it takes the high time to generate the rules.

Shanmugasundharam et al. (2017) investigated the south-western part of the Vellore district in India, which is bordered by the Andhra Pradesh state. The influence of tanning businesses on groundwater in Ambur, Vellore district, Tamil Nadu, India was studied by Kanagaraj and Elango (2016). The groundwater is unfit for drinking in over 80% of the sampling locations due to high concentrations of main ions in the groundwater.

4.2.2 Analysis in Uttara Pradesh

In their works Ansari and Umar (2019), Yadav et al. (2018), Saleem et al. (2016), Madhav et al. (2018) and Singh et al. (2013), numerous scholars examined different regions of Uttar Pradesh (UP). In Unnao District, Uttar Pradesh, Ansari and Umar (2019) evaluated 68 groundwater samples. Saleem et al. (2016) investigated 10 distinct areas in Uttar Pradesh's Noida (Region) (UP). In their investigation, 90% of water samples were judged to be of acceptable quality, with only 10% falling into the moderately poor category. Madhav et al. (2018) examined 20 samples collected in Sant Ravidas Nagar (Bhadohi), Uttar Pradesh. According to the water quality index, the entire sample falls into the excellent water category.

Khan and Khan (2019) investigated the area around Aligarh in western Uttar Pradesh, India, where the river Kali flows. The findings are crucial for groundwater quality management and protection in riparian aquifers along the Kali Nadi. Yadav et al. (2018) studied 28 samples in Agra, Uttar Pradesh. Singh et al. (2013) evaluated 60 samples from the Allahabad district, Northern India, research region.

4.2.3 Analysis in Multiple States

The quality of groundwater in various Indian states is examined in this section. The fuzzy-AHP approach was used by Das and Pal (2019) to investigate groundwater recharge potential zones in the Goghat-II block of West Bengal, India. It is categorised as very low, low, moderate, high, and very high potentiality, with 8.98%, 34.58%, 33.51%, 12.80%, and 10.13%, respectively, based on the analysis. Similarly, Thapa et al. (2019) gathered 50 samples from Gharbar village in Jharkhand, India, and investigated the quality of the groundwater.

The area of Kanavi Halla Sub-Basin, Belagavi, Karnataka, India, was studied by Patil et al. (2020). The 29 samples were obtained by Kumar et al. (2020) from the Indus basin in India. The 40 samples were obtained by Sajeev et al. (2020) from the Vembanad Lake area in Kerala, India. The presence of a strong link between the host rock and groundwater quality suggested that there was significant water-rock interaction.

4.3 Case Study Analysis of Various Districts in Tamil Nadu

In the sub section, the groundwater quality is analyzed in various SIPCOT industries areas like as Erode, Tuticorin coastal city, Salem, Tirupur, Karur, Chennai, Vellore, Kanyakumari, and Gulf of Mannar from South Coast of TN referred from the papers Abijith et al. (2020), Selvakumar et al. (2017), Duraisamy et al. (2019), Durgadevagi and Annadurai (2016), Selvam et al. (2016), Arulbalaji and Gurugnanam (2017), Muralitharan and Palanivel (2018), Subramani et al. (2012), Arumaikkani et al. (2017), Shankar et al. (2010), Selvam et al. (2018), Kalaivanan et al. (2018), Krishna kumar et al. (2015), Selvakumar et al. (2017), Selvam et al. (2017), Srinivas et al. (2017), Anbarasu et al. (2020), Vetrimurugan et al. (2017), Brindha et al. (2017), Durgadevagi and Annadurai (2016), Shanmugasundharam et al. (2017), Singaraja (2017), Singh et al. (2013), Srinivas et al. (2013), Sajeev et al. (2020), Kanagaraj and Elango (2016), Senthilkumar and Meenambal (2007) and Madhav et al. (2018) and respectively. Some of the important regions are analyzed and reviewed. From the below Table 4, it shows that the various areas groundwater quality and mentioned their advantages and disadvantages.

Analysed the quality of groundwater in various industrial locations around Tamil Nadu, India. Anbarasu et al. (2020) have analysed and identified the land use, geomorphology features and slope the highest weights impact on the groundwater potential zones. Kanagaraj and Elango (2016) have analysed the dominant source for ionic contents is due to tannery effluents and cation exchange processes. Vetrimurugan et al. (2017) have analysed groundwater quality and surface water in Cauvery river basin area

Table 4. Review of Various Areas in Tamil Nadu

Author names	Year	Study Area	Advantages	Disadvantages
Anbarasu et al.	2020	Perambalur District	GWPZ areas identified	Management actions are required to evaluate the water quality ranges.
Kanagaraj and Elango	2016	Vellore District	Groundwater recharge can be improved using reverse osmosis and rainfall recharge structures.	Fail to analyze the GWPZ and evaluate water quality
Vetrimurugan et al.	2017	Cauvery river basin	Groundwater quality based on heavy metals' concentration are evaluated	Various areas are required to analyze the geo-chemical parameters of groundwater
Durgadevagi and Annadurai	2016	Erode District	GIS method tool is used	Regions of low groundwater quality should be analyzed
Senthilkumar and Meenambal	2007	Erode District	Near SIPCOT industries areas are analyzed	Industrial effluents must be properly disposed of, and groundwater must be monitored on a regular basis.

pose large threat due to high levels of heavy metals concentration, and it is necessary to avoid this water for drinking due to potential risk of human health hazard. Durgadevagi and Annadurai (2016) aims to identify the groundwater quality and pollution under very highly vulnerable zone using a GIS based DRASTIC model. Senthilkumar and Meenambal (2007) analysed the physico-chemical groundwater quality parameters of groundwater like pH, turbidity, colour, odour, electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, iron, nitrate, chloride, fluoride and sulphate from the SIPCOT industrial area. From the overall analysis, the groundwater zones are monitored and recharged according to their affected groundwater with the physicochemical materials.

4.3.1 Analysis of Erode District

The groundwater quality is assessed mostly in the Erode district's SIPCOT industrial region. Senthilkumar and Meenambal (2007) gathered 11 samples in Erode District from 11 villages. According to their findings, groundwater near the SIPCOT region is unfit for human consumption on a number of levels. The 35 samples were obtained by Durgadevagi and Annadurai (2016) from the SIPCOT region of Perundurai, Erode. Durgadevagi and Annadurai (2016) conducted a study on Erode's SIPCOT region, finding that more than 62 percent of the groundwater in and surrounding the SIPCOT area is in a very high susceptible zone.

4.3.2 Analysis of Tuticorin District

In the Ottapidaram Taluk, Thoothukudi District, Tamil Nadu, Selvam et al. (2018) collected 34 groundwater samples. In comparison to the rest of the region, the southern section is less polluted. In the Thoothukudi District, Singaraja (2017) gathered 100 groundwater samples. The degree of groundwater quality is indicated in Fig. 5. This will assist us in determining the utility purpose of water and managing this commodity in light of seasonal variations.

Selvam et al. (2017) collected 36 groundwater samples in the Tuticorin area from open wells and bore holes. Fig. 6 shows that the groundwater quality and irrigation quality in Tuticorin districts.

4.3.3 Analysis of Coimbatore City

Selvakumar et al. (2017) investigated the Singanallur Sub-basin, which is one of the primary streams that provides water to Coimbatore. The Cauvery River Basin in Tamil Nadu, India, was studied by Vetrimurugan et al. (2017).

4.3.4 Analysis of Salem Region

Arulbalaji and Gurugnanam (2017) examined water quality research in the Salem area and assessed water quality in Tamil Nadu for home and irrigation applications. Only 3% of samples are unfit for irrigation, which is suspicious.

4.3.5 Analysis of Kanyakumari Region

Srinivas et al. (2013) and Srinivas et al. (2017) have analyzed in Nagercoil surroundings area. In Nagercoil, 21 groundwater samples were obtained from boreholes and hand pumps. Only 38 percent of the samples are totally appropriate for drinking, according to the WQI categorization, as shown in Figure Srinivas et al. (2017) On the shore of Manavalakurichi, the quality of groundwater was assessed, and 30 groundwater samples were obtained at random from open wells and boreholes. As a consequence, among the 30 well samples, it was discovered that the groundwater in three wells in the research area is more dangerous, as shown in Fig. 7.

Other salt-tolerant crops and good drainage are required in these places.

4.3.6 Analysis of Nilgiri, Karur, Trichy and Perambalur Region

Subramani et al. (2012) looked at 13 sampling stations in the Nilgiris' Coonoor Taluk. According to their findings, the Kunour area is under threat from significant challenges such as pollution and water scarcity. Groundwater samples were studied by S Selvakumar et al. (2017) in the southern Tiruchirappalli area. According to TDS, 55 percent of the samples are drinkable, while the remaining samples are not.

In the Karur district, 32 geochemical samples of groundwater were collected before the monsoon (July 2012) and after the

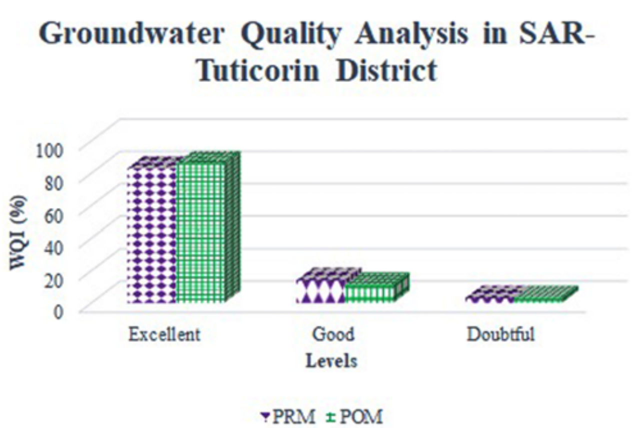

Fig. 6. Analysis of SAR

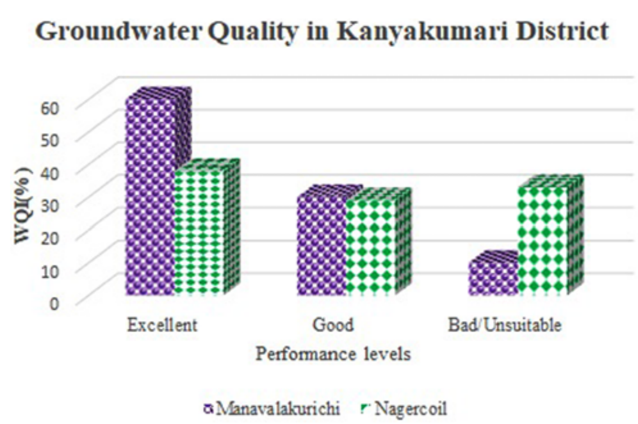

Fig. 7. Comparison of Groundwater Quality Index Levels in Kanyakumari District

monsoon (January 2013) by Muralitharan and Palanivel (2018).

4.3.7 Analysis of Vellore Region

Shanmugasundharam et al. (2017) have collected thirty-one groundwater samples in Tamil Nadu's Krishnagiri and Vellore districts. According to their findings, 52% of the samples are in very excellent to good condition, while 6% are in the good to permissible category, indicating that the water is ideal for irrigation.

4.4 Comparison Analysis Health related issues

In the section, the comparison parts of analysis is presented in the state of Punjab, India. In the previous section, most of the areas are analyzed from the Tamil Nadu area. Here, the physico-chemical parameters, water quality indices, heavy metal contents (cadmium, cobalt, chromium, copper, lead and zinc) and possible health risks posed to adults and children during summer and winter seasons. Additionally, the cancer hazard quotients are determined and depicted in the Fig. 8(b). For the analysis process, the cobalt is higher than the ‘1’ (>1), the cancer hazard is raised automatically, and it is risked when it reaches the levels (>6). The chromium also used to affect the humans the problem of cancer (Sharma et al., 2019). Hazard quotients (HQs) for different heavy metals and hazard index (HI) for children and adults from the study area during summer and winter seasons is depicted in the Fig. 8(a). Children were more susceptible to health problems than adults due to their smaller body weight, with a higher risk in the winter, which could be attributable to higher heavy metal contamination in groundwater during monsoon leaching. The results of the water quality analysis and risk assessment revealed that the groundwater had been significantly contaminated, and that if used without pre-treatment for an extended period of time, it could pose serious health risks to humans via drinking water and irrigation of agricultural fields due to bio concentration of heavy metals in the food crops cultivated in those fields. The daily consumption of heavy metals in the drinking water is already defined and this is evaluated to analyze the factors of Non-cancer health hazard quotients (HQs). The standard limits are specified in the paper (USEPA, 1989):

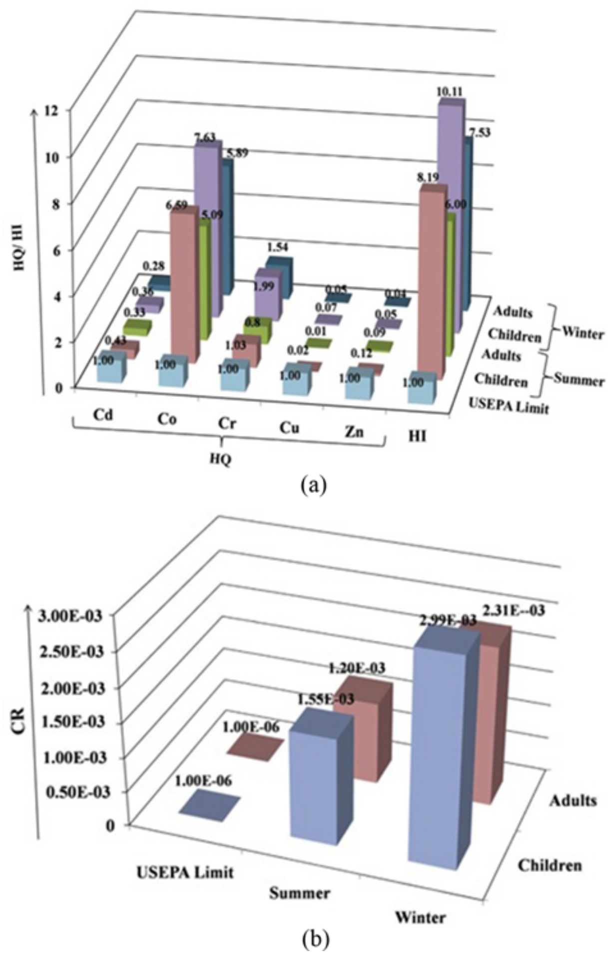

Fig. 8. Analysis of: (a) Hazard Quotients, (b) Cancer Risks under Winter and Summer Period

An overview of groundwater quality analysis in various regions of India and Tamil Nadu shows a certain degree of malpractice and its importance are shown. In most cases, WQI and chemical parameters need to be determined and evaluate the groundwater level. The comparative study of the review focuses on groundwater quality and potential zones, as shown in above illustrations. It is mainly designated as various research papers and their limitations, and is useful for treating groundwater quality levels. In this regard, awareness of groundwater quality is important for all people. From the overall analysis, most of the areas are in India is suitable for drinking and irrigation purpose, at the same time, some of areas are needed to be monitored. Because these are may be polluted and quality level is decreased with presence of chemical parameters. Therefore, the groundwater monitoring and zone identifications is necessary for all areas, it may prevent the region affected from the industrial wastes.

5. Conclusions

In the paper, various areas presented in India are reviewed and analyzed their groundwater quality levels. As per the analysis, the WQI results shows that the range of excellent water (10%), good water (42%), and bad water (48%) samples for household and irrigation uses. From the analysis, the bad water samples (range 44%) were largely found in the western region. The groundwater was heavily contaminated as a result of agricultural wastes, fertiliser use, soil leaching, sewage, livestock waste, and urban runoff. In the southern portion of India, more than half of the samples are excellent water which shows that the 20% are decent water, and 30% are poor water. Because some groundwater samples in the research area contain excessive salinity, hardness, and magnesium concentrations, they are unsuitable for irrigation. If it is used for irrigation, it will have an adverse effect on plant growth and contaminate soil quality. Farmers should make a concerted effort to reduce the impact of agricultural runoff. The government must take the initiative and raise awareness about the dangers of excessive fertiliser use. Government, management, and maintenance should all be in charge of anthropogenic activities, and they should carry over to water resources to prevent contamination. The pollution of chemical factors in ground water quality levels is examined in the southern area. For the comparison purpose, other countries areas are considered and reviewed. Almost half of the samples fall into the ‘bad’ category, while the other half fall into the ‘very poor’ and ‘unfit for drinking purposes’ categories, according to the water quality index. As a result, prior to human ingestion, proper treatment and remediation approaches are required. With the help of a GIS tool, spatial distribution maps transmitted possible information about the total water quality distribution in each study region, and they are a useful strategy for monitoring, management, and future modelling. In future, groundwater recharge zones are identified as earlier stage based on the GIS tools with the Artificial Intelligence (AI) techniques. The prediction results are estimated to prevent the dangerous zones and the groundwater quality level must be protected.

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