



## Study on Review of Literature of Quality Assessment of groundwater in India

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**Abstract:** It is essential to ensure proper quality of water used for drinking and irrigation purposes. Use of inferior quality of water for drinking will adversely affect human health. In developing countries like India, most of the population use untreated groundwater for various purposes, as they do not have access to good quality water. The chemical hazards are the Calcium, Magnesium, Nitrate etc. As the public health concern, the groundwater should be free from physical and chemical hazards. The environmental problems existing impact on groundwater quality have been the most prominent in the recent years. The Contamination of groundwater is the major environmental risk. Suitability of groundwater for drinking purposes depends upon its quality has been identified as one of the major threats to groundwater resources not only in India but throughout the world. The drinking quality of water depends on various suspended, dissolved and biological constituents. The Bureau of Indian Standards (BIS 2003) and the World Health Organization (WHO 2006) have prescribed maximum permissible limits for various dissolved ions in water used for human intake. Researchers around the world have studied the quality of water based on these standards.

[Kawar singh. **Study on Review of Literature of Quality Assessment of groundwater in India.** *N Y Sci J* 2023; 16(9):1-6].ISSN 1554-0200 (print);ISSN2375-723X (online).<http://www.sciencepub.net/newyork>. 01.[doi:10.7537/marsnys160923.01](https://doi.org/10.7537/marsnys160923.01).

**Keywords:** Review of Literature, Quality Assessment, Groundwater, India

### Introduction:

Earth is also called as 'blue planet' because 70 per cent area of it has been covered by water resource. The total water amount on the earth is about 1.35 billion cubic kilometers. About 97.1 per cent has been locked into oceans as saltwater. Ice sheets and glaciers have arrested 2.1 per cent. Only 0.2 per cent is the fresh water present on the earth, which can be used by human for variety of purposes. Remaining 0.6 per cent is in underground form (Anonymous, 2007). But unfortunately, it has been getting polluted day by day due to different anthropogenic activities. The effects of water pollution are not only devastating to people but also to animals, fish, and birds. Polluted water is unsuitable for drinking, recreation, agriculture and industrial purposes. It diminishes the aesthetic quality of lakes and rivers. More seriously, contaminated water destroys aquatic life and reduces its reproductive ability. Eventually, it is a hazard to human health and nobody can escape the effects of water pollution. Therefore, it is burning need, to conserve the water and prevent it from every type of pollution. Geographical Information System (GIS) has multiple meanings and the widely accepted views are the effectiveness of map processing, databases and spatial analysis with the help of human expertise. GIS integrates geographically referenced

spatial and non spatial data required at different scales and times, and in different formats.

### Review of Literature:

Review of Literature Rahman et al. (2009) illustrated the statistical evaluation of the arsenic polluted groundwater to identify the correlation of arsenic with other participating groundwater parameters so that the arsenic contamination level can easily be predicted by analyzing only those parameters. Multivariate data analysis carried out with the collected groundwater from the 67 tubewells of the contaminated aquifer suggests that arsenic may have substantial positive correlations with Fe, Mn, Al, HCO<sub>3</sub> and PO<sub>4</sub> whereas noticeable negative relationships were observed with SO<sub>4</sub>, Cl and NO<sub>3</sub>. Based on these relationships, a multiple linear regression model was developed that incorporates seven most influential groundwater parameters as the independent predictor variables to estimate the as contamination level in the polluted groundwater.

Lanyon et al., (1982) have attempted the observation of two-dimensional variations in groundwater level on beach profiles at South Beach, Wollongong, support and extend observations previously reported. Time-series curves showing water-level change at individual wells along the profiles are

markedly asymmetrical and their ranges of oscillation are dependent on tidal range and distance landward of the beach face. The asymmetry is attributed to filtering processes at the beach face and in the beach that separate the various tidal constituents. Tidally induced groundwater changes are superimposed on a three-dimensional water-table surface that is tied to the beach morphology and groundwater recharge from the backshore zone. The groundwater rise begins earliest in shoreline embayment and spreads landwards and outwards to higher water-table surfaces near shoreline salient and in the backshore zone. Groundwater responses, therefore, differ on the salient and in the embayments: a landward watertable slope prevails in the embayments and a seaward slope characterizes the salient.

Alhumoud et al. (2010) examined the interrelationships between the TDS, electrical conductivity (EC), sodium ( $\text{Na}^+$ ), potassium ( $\text{K}^+$ ), calcium ( $\text{Ca}^{2+}$ ), magnesium ( $\text{Mg}^{2+}$ ), chloride ( $\text{Cl}^-$ ), sulfate ( $\text{SO}_4^{2-}$ ), and bicarbonate ( $\text{HCO}_3^-$ ) to trace out the groundwater quality trends of the Dammam Formation aquifer of Al-Sulaibiya field, Kuwait during the period 1991–2005. Al-Sulaibiya field is the oldest and the largest groundwater well field producing brackish groundwater from the Dammam Formation aquifer. Total dissolved solids (TDS) values of the Dammam Formation aquifer of Al-Sulaibiya field are very high and found in the range of 3523–9460 mg/l. The study revealed that, the variable most strongly correlated with TDS was electrical conductivity (EC).

Van der Kamp and Maathuis, (1991) worked on the long-term hydrographs for deep confined aquifers in southern Saskatchewan, Canada, show annual fluctuations characterized by a gradual rise in the head from October to May/June and a rapid drop from May/June to October. These fluctuations are distinctly different from the seasonal fluctuations observed in surficial and shallow semi-confined aquifers, which reflect the response of these aquifers to recharge derived from snowmelt and early spring rains. On the basis of field data and theoretical considerations, it is demonstrated that seasonal fluctuations of the water table are not transmitted down to the deep aquifers, provided the confining layers are thick and have sufficiently low hydraulic diffusivity. The annual fluctuations in the deep aquifers thus do not reflect seasonal recharge to these aquifers. It is postulated that the annual head fluctuations in the deep confined aquifers reflect changes of the mechanical load on the formations, caused by seasonal changes of the soil moisture, snow, and storage at the water table. The deep confined aquifers thus act as large-scale, inexact, weighing lysimeters.

Bu et al. (2010) applied cluster analysis, discriminant analysis, and factor analysis techniques to

analyze the physical and chemical variables in order to evaluate water quality of the Jinshui River, a water source area for an inter basin water transfer project of China. Cluster analysis classifies 12 sampling sites with 22 variables into three clusters reflecting the geo-setting and different pollution levels. Discriminant analysis confirms the three clusters with nine discriminant variables including water temperature, total dissolved solids, dissolved oxygen, pH, ammoniacal nitrogen, nitrate nitrogen, turbidity, bicarbonate, and potassium. Factor analysis extracts five varifactors explaining 90.01 per cent of the total variance and representing chemical component, oxide-related process, natural weathering and decomposition processes, nutrient process, and physical processes, respectively. The study demonstrates the capacity of multivariate statistical techniques for water quality assessment and pollution factors/sources identification for sustainable watershed management. Chatterjee et al. (2010) worked on the groundwater quality assessment of Dhanbad district, Jharkhand, India. Groundwater quality assessment is important to ensure sustainable safe use of water. The overall water quality in the Dhanbad coal mining area of India is difficult due to the spatial variability of multiple contaminants and wide range of indicators that could be measured. An attempt was made to study the spatial variation of groundwater quality based on an integrated analysis of physico-chemical parameters and use of Geographic Information System. Using GIS contouring methods spatial distribution maps of Hardness, pH, TDS,  $\text{HCO}_3$ ,  $\text{SO}_4$ ,  $\text{NO}_3$ , Ca, Mg, Cl, and F were created.

Jan et al., (2007) investigated the relationship, we first employed the BAYTAP-G program to filter out the response of the groundwater level to non-rainfall effects, such as barometric pressure and earth tide. Because both the present and antecedent rainfall events give an impact on the groundwater level increment, an effective accumulated rainfall amount was defined to account for their influences using the exponential-decay weighting method. The resulting groundwater level, conventionally termed the residual groundwater level, was found to linearly depend on the effective accumulated rainfall amount. Lastly, we demonstrated that rainfall occurring beyond the surface watershed within which the Donher well station locates indeed affects the residual groundwater level.

Gabrial and Donatus (2010) studied physicochemical parameters related to groundwater quality obtained from Yola area of Northeastern Nigeria. They developed linear regression equations to predict the concentration of water quality having significant correlation coefficients with electrical conductivity (EC). The TDS and EC have perfect correlation coefficients whereas Na and Cl, are highly correlated in all the water sources. Furthermore, while Ca and  $\text{HCO}_3$

are highly correlated in both the shallow and deep groundwater it has relatively lower correlation coefficients in the surface water samples. It was equally observed that Mg, Ca, NO<sub>3</sub>, Cl and Fe are highly correlated with EC in surface water samples. The data also indicated that apart from surface water bodies Ca, NO<sub>3</sub>, Cl and HCO<sub>3</sub> are poorly related with electrical conductivity at 5 per cent level of significance.

Shamsudduha et al., (2009) resolved trend and seasonal components in weekly groundwater levels in the Ganges-Brahmaputra-Meghna (GBM) Delta, we apply a nonparametric seasonal-trend decomposition procedure (STL) to observations compiled from 1985–2005 in Bangladesh. Seasonality dominates observed variance in groundwater levels but declining groundwater levels (>1 m/yr) are detected in urban and peri-urban areas around Dhaka as well as in north-central, north-western, and southwestern parts of the country (0.1–0.5 m/yr) where intensive abstraction of groundwater is conducted for dry-season rice cultivation. Rising groundwater levels (0.5–2.5 cm/yr) are observed in the estuarine and southern coastal regions. This novel application of the STL procedure reveals, for the first time, the unsustainability of irrigation supplied by shallow aquifers in some areas (e.g., High Barind Tract) of the GBM Delta and the hydrological impact of potential seawater intrusion of coastal aquifers associated with sea-level rise.

Machiwal et al. (2010) focused on a GIS-based assessment and characterization of groundwater quality in a semi-arid hard-rock terrain of Rajasthan, western India using longterm and multi-site post-monsoon groundwater quality data. Spatio-temporal variations of water quality parameters in the study area were analyzed by GIS techniques. GIS analysis revealed that sulphate and nitrate ions exhibit the highest (CV>30%) temporal variation, but groundwater pH is stable. Hardness, EC, TDS, and magnesium govern the spatial pattern of the GWQI map. The groundwater quality of the study area is generally suitable for drinking and irrigation (median GWQI >74). Ramkumar et al. (2010) attempted to determine the groundwater quality in parts of Vedaraniyam region, Tamilnadu. Totally, eighty groundwater samples were collected from open dug wells, covering three seasons (Post-monsoon, summer and pre-monsoon seasons) and analyzed for physicochemical parameters (pH, EC, TDS, TH, Na, K, Ca, Mg and Cl, SO<sub>4</sub>, HCO<sub>3</sub>, NO<sub>3</sub>) in order to understand the hydro geochemistry of the water. The results of analysis were interpreted with geology and geomorphology of the area and by various geochemical diagrams such as Piper trilinear plot and USSL classification diagram. Suitability of this water for its utility was verified using Indian standards. The results of the study indicates that only one well was suitable for drinking purpose and remaining others were suitable for

domestic and irrigation purpose. Further, the results indicates that most of the well water falls in Na-Cl type indicating the influence of seawater in these wells, which is confirmed by Piper plot.

Bhuiyan, (2010) carried out a study to the assessment of relations between water-level fluctuations (WLF) with various hydrogeological factors that is not straightforward. In the present study, various hydrogeological factors that could influence aquifer recharge in the deformed crystalline Aravalli terrain of India have been analyzed. Frequency plots have been used to assess the variations in WLF under different geological parameter classes. Seasonal WLF associated with these factors have been compared using various statistical parameters. Parametric and non-parametric statistical tests have been used to determine the statistical significance of fluctuation difference. The study infers that saturated thickness, lineament, lineament-intersection, and drainage beside surface elevation and well depth are the main geological factors influencing aquifer recharge in the Aravalli terrain. Median values under these factors are integrated and compared with the interpolated values of mean WLF at hypothetical well locations. They are found to closely resemble each other. This infers the capability and applicability of the technique in identifying key factors governing WLF, and in predicting WLF at unexplored locations.

Tank and Chandel (2010) studied the hydrochemistry of groundwater in Jaipur city to assess the quality of groundwater for determining its suitability for drinking and agricultural purposes. Groundwater samples were collected from eleven stations of Jaipur city during monsoon season and were analyzed for physico-chemical parameters such as pH, EC, TDS, sodium, potassium, calcium, magnesium, chloride, sulphate, carbonate, bicarbonate, nitrate and fluoride. Comparison of the concentration of the chemical constituents with WHO drinking water standards of 1983, the status of groundwater is better for drinking purposes. Results indicate that nitrate concentrations are in an alarming situation with respect to the use of groundwater for drinking purposes. The calculated values of SAR, RSC and percentage sodium indicate that the water is excellent for irrigation. US Salinity diagram was used for evaluating the water quality for irrigation which suggests that the majority of the groundwater samples were good for irrigation. Patil and Patil (2011) analyzed the groundwater samples during November 2007-February 2008 (Three open wells, three tube wells) collected from six different locations around Amalner town. Fifteen physicochemical parameters were analyzed and the results were compared with water quality standards prescribed by WHO and ISI 10500-91. The study revealed that two water samples (one open well, one tube well) showed high EC, TDS, TA, TH

values indicating poor water quality. The correlation coefficients were also calculated.

Tiwari et al., (2017) studied the groundwater-level monitoring has been carried out on 26 observation dug wells in the Aosta Valley region, Italy, during the dry season (June 2013) and wet season (November 2013) in order to assess the water-level fluctuation (WLF). The depth to water level varied from 3.04 to 28.70 meters below ground level (mbgl) in the dry season and from 2.92 to 25.62 mbgl in the wet season. The WLF of the study area varied from 0.01 to 6.80 mbgl, and the western and north-western regions of the study area showed higher WFL. The WLF map was validated with a statistical analysis and elevation value of the area in a geographic information system environment, and this indicated that validation can be accepted for the WLF in the Aosta Valley. The results of the study demonstrated that the eastern region could be considered as a safe and good recharge zone for the groundwater in the Aosta Valley region.

Deshpande and Aher (2012) conducted study to evaluate factors regulating groundwater quality in an area with agriculture as main use. Fifteen groundwater samples have been collected from Vaijapur taluka of Aurangabad district. The Vaijapur taluka of Aurangabad district covers an area of approximately 1510.5 km<sup>2</sup> and underlain by the Deccan Trap lava flows of upper Cretaceous to Eocene age. Rapid development in recent years has led to an increased demand for water, which is increasingly being fulfilled by groundwater abstraction. A detailed knowledge of the water quality can enhance understanding of the hydrochemical system, to achieve this; a hydrochemical investigation was carried out in the study area. Groundwater samples were chemically analyzed for major physicochemical parameter in order to understand the different geochemical processes affecting the groundwater quality. The analytical results shows higher concentration of total dissolved solids (26.66%), electrical conductivity (26.66%), chloride (33.33%), total hardness (60%) and magnesium (86.66%) which indicates signs of deterioration as per WHO and BIS standards. On the other hand, 40% groundwater sample is unsuitable for irrigation purposes based on irrigation quality parameters. The study revealed that application of fertilizer for agricultural contributing the higher concentration of ions in aquifer of Vaijapur.

Anand et al., (2020) worked on the long-term trend detection and spatiotemporal variation of groundwater levels were analyzed using Geographical Information System (GIS) and performing statistical tests for the Lower Bhavani River basin, Tamil Nadu, India. For this purpose, 32 years of long-term groundwater-level data (1984–2015) of 57 observation wells spread over the study area were collected from the government departments. Seasonal variation of

groundwater levels was plotted spatially for premonsoon (March to May), post-monsoon (January and February), southwest (SW) monsoon (June to September) and northeast (NE) monsoon (October to December) seasons using GIS. The trend variation of groundwater levels was predicted by performing statistical tests such as Mann–Kendall test and Sen's slope estimator. The present study indicates that the average annual groundwater level has lowered beyond 15 m (below ground level) during all the monsoon seasons in the years 2003 and 2004, which highlights less rainfall infiltration and overexploitation of groundwater. This leads the hard rock aquifer into stress. The study also shows that the groundwater fluctuation is very high in the southeastern and north-eastern parts of the basin, and it is moderate in the northern and north-western parts of the basin. However, the fluctuation is comparatively less in the central part of the basin because of the replenishment of groundwater by the Bhavani River.

Deshapnde et al. (2012) evaluated the quality of groundwater in Warora tehsil, District Chandrapur, India for its suitability for drinking purposes. Sixty groundwater samples were collected during pre-monsoon period of the year 2011 and analyzed for various parameters. Physical and chemical parameters of groundwater such as electrical conductivity, pH, total dissolved solids, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup>, CO<sub>3</sub><sup>2-</sup>, HCO<sub>3</sub><sup>-</sup> and SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>, PO<sub>4</sub><sup>-</sup>, and F<sup>-</sup> were determined. The value of TDS, Cl<sup>-</sup> and SO<sub>4</sub><sup>-</sup> ion concentration is within the limits in majority of the samples. The excess amount of Ca<sup>++</sup>, Mg<sup>++</sup>, TH and NO<sub>3</sub><sup>-</sup> and F<sup>-</sup> in the groundwater is due to anthropogenic factors and geological characteristics of the aquifer. Assessment of groundwater samples indicated that groundwater in study area is chemically not suitable for drinking uses. Total hardness (25%), Calcium (59%), Magnesium (13%), fluoride (50%) and nitrate (17 %) are crosses the maximum permissible limits for human consumption as per the drinking water standards.

Sondhi et al., (1989) have determined the available additional groundwater potential and its distribution in the Mahi Right Bank Canal Project in Gujarat is presented. The procedure is based on the use of specific empirical constants for estimating groundwater recharge from the water conveyance and distribution system and the annual water balance of the project. The spatial distribution of groundwater potential is determined by "recharge distribution coefficients" derived from a digital simulation model of the groundwater basin of the project area. The annual groundwater potential are obtained in the Mahi Right Bank Canal project in India is about 265 × 106 m<sup>3</sup>. This is about 1.6 times the existing level of groundwater abstraction. The spatial distribution of this potential over



the project area is not uniform. It is relatively high in the central and southern portions of the project area and is low at the northern and western boundaries.

Ming Kuo et al. (2013) identified the nearshore groundwater and river hydrochemical variables influencing water quality of Kaoping River Estuary in Taiwan using dynamic factor analysis. This study attempts to determine the main factors regulating temporal and spatial variations in the water quality in the Kaoping River Estuary over a 9-year period (2003–2011), using dynamic factor analysis (DFA) and min/max autocorrelation factor analysis (MAFA). The result from the MAFA shows that Chlorophyll-a (Chl-a) has the highest canonical correlation coefficient with the min/max autocorrelation factor (MAF) axis of water quality. Therefore, Chl-a can be used as an indicator of water quality in the Kaoping River Estuary. The water quality and environmental variables measured downstream of the Kaoping and Tungkan Rivers, as well as submarine groundwater, influence temporal variations of Chl-a in the estuary. The optimal DFA model successfully described Chl-a variations (coefficient of efficiency = 0.969) in the Kaoping River Estuary. DFA results indicate that dissolved oxygen (DO), total suspended sediment (TSS), dissolved inorganic nitrogen (DIN), chemical oxygen demand (COD), as well as the biological oxygen demand (BOD) of river discharge, and the ammonium–nitrogen (NH<sub>4</sub>–N) concentration of groundwater discharge significantly influenced Chl-a dynamics. Pandian and Jeyachandran (2014) studied groundwater quality mapping using Remote Sensing and GIS – A Case Study at Thuraiyur and Uppiliapuram Block, Tiruchirappalli District, Tamilnadu, India. Arc GIS tools were used for analyzing and displaying the spatial data for investigating the ground water quality information. The EC in the study area ranges from 3000 and the area has been classified as 5 classes.

Shahid et al., (2000) used the Geographical Information System (GIS) integration tool is proposed to demarcate the groundwater potential zone in a soft rock area using seven hydrogeologic themes such as lithology, geomorphology, soil, net recharge, drainage density, slope and surface water bodies. Except for net recharge and slope, the other five themes are derived from remote sensing data. IRS-1B LISS-II data was used for a 631 km<sup>2</sup> area in Midnapur District, West Bengal, India. While the slope was calculated using topographic sheets, net recharge was obtained from annual water table fluctuation data. Each feature of all the thematic maps was evaluated according to its relative importance in the prediction of groundwater potential. The evolved GIS-based model of the study area was found to be in strong agreement with available borehole and pumping test data.

Vittala et al., (2005) evaluated to delineate groundwater potential zones based on the characteristics of geomorphic units together with slope, geology, lineaments, bore well data using Remote Sensing and Geographic Information System (GIS) techniques. The slope varies from nearly level (0-1%) to very steep (>35%). The different geomorphic units in each sub-watershed consist of denudational hills, residual hills, inselbergs, pediment inselberg complex, pediments, shallow weathered pediplains, moderately weathered pediplains and valley fills. The lineament map for each sub-watershed has been prepared and the trends were analyzed with rose diagrams. The analysis of borewell locations and their yield data in association with lineaments at sub-watershed level reveals that the lineaments are acting as a pathway for groundwater movement. The integrated map comprising groundwater potential zones prepared by "Union" function using GIS indicate that valley fills and moderately weathered pediplains are very good to good, shallow weathered pediplains are good to moderate, pediment inselberg complex and pediments are moderate to poor and denudational hills, residual hills and inselbergs are poor to very poor groundwater prospect zones.

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