International Journal of Geography and Geology
2021 Vol. 10, No. 1, pp. 1-8.
ISSN(e): 2305-7041
ISSN(p): 2306-9872
DOI: 10.18488/journal.10.2021.101.1.8

EVALUATION OF GROUNDWATER QUALITY USING WATER QUALITY INDEX IN GADILAM RIVER BASIN, TAMIL NADU, INDIA

K. Mohammed Rizwan[1]
V. Thirukumaran[2+]

[1,2]Department of Geology, Government Arts College (Auto), Salem, India.
Email: mail_kumaran@yahoo.co.in Tel: +919600980777

(+ Corresponding author)

Article History
Received: 26 May 2021
Revised: 21 June 2021
Accepted: 13 July 2021
Published: 30 July 2021

Keywords
Gadalim River
Groundwater
Archaean
Quaternary
Tertiary
Cretaceous
Water quality index.

ABSTRACT

The current research is to assess the groundwater quality the Gadilam river which is draining in the northern part of the Tamil Nadu and to examine its suitability for irrigation uses. The groundwater quality parameters are derived from 120 groundwater samples collected throughout the basin out of which 50 samples are from Archaean formation, 34 samples are from Quaternary formation, 35 samples are from Tertiary formation and the remaining one sample is from Cretaceous formation. In addition to that, this study involves comparing the determined cations and anions levels with the various standards for drinking. The variability of parameters of the groundwater quality is explored by using statistical method. The conclusion of this research reveals that the groundwater quality parameters like Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Nitrate (NO_3^{2-}), Fluoride (F^-), Sulphate (SO_4^{2-}), Bi-carbonate (HCO_3^-) and Percentage of Hydrogen (pH) values are observed within limiting value for WHO 2011 in all the formations during this season. WQI values for the Archaean, Quaternary and Tertiary formations are found lesser than 100 meq/L in all stations in monsoon seasons. Based on WQI, these sample stations are coming under the category of "Excellent" and "Good".

Contribution/Originality: This study is one of very few studies which have investigated and compared the water quality Index for different geological formations of Gadilam river basin.

1. INTRODUCTION

Groundwater is utilised for a variety of reasons across the world, including irrigation, home, and industrial usage. Because of the continual increase in population, pollution has increased during the previous few decades. As a result of the rapid growth in population and the increased pace of advancement in industrialization, there is a huge increase in the need for fresh water. Water quality degradation has become a worldwide problem of concern as human populations grow, agricultural and industrial activities expand, and climate change threatens to impact dramatic changes in the hydrological cycle (Federation & APHA, 2005).

According to the World Health Organization (WHO), water is responsible for about 80% of all human illnesses (WHO, 2011). As a result, in order to examine the water characteristics, the quality of water must be presented in the most common form. When groundwater is polluted or deteriorated, its quality does not recover by stopping pollutants from entering the system at the source. The drinking water quality rules and regulations are intended to provide for the provision of properly clean and protected water for human consumption, hence protecting people's health. As a result, it is critical to regularly monitor and safeguard groundwater quality.

The main goal of any evaluation for groundwater quality is frequently to obtain an all-inclusive variation of groundwater quality and analyze the changes in time that occur in groundwater quality, either naturally or as a result of man's demand (Tiwari & Nayak, 2002).

Several writers have investigated the hydrogeochemistry of groundwater and the aquifer's sensitivity to contamination in the peninsular India hard rock aquifer. Rina, Dutta, and Mukherjee (2011) and Singh et al. (2012a); Singh, Rina, Singh, and Mukherjee (2012b) investigated groundwater hydrogeochemical evolution. Prasanna, Chidambaram, Hameed, and Srinivasamoorthy (2011); Sonkamble, Sahya, Mondal, and Harikumar (2012) Brindha, Vaman, Srinivasan, Babu, and Elango (2013); Brindha. and Kavitha (2014); Kumar, Logeshkumaran, Magesh, Godson, and Chandrasekar (2014); Rajesh, Brindha, and Elango (2015) investigated aquifers in various rock domains such as granite, gneiss, schist, and basalt to enumerate the geochemical evolution.

Water quality index (WQI) is the most important instrument for communicating information about water quality to concerned individuals and policymakers. It is an effective approach for determining the properties of water (Mishra & Patel, 2001; Naik & Purohit, 2001; Singh, 1992). As a result, the water quality index becomes an important indicator in groundwater management and assessment. It can aid in the classification of groundwater, determining whether or not it is suitable for irrigation. WQI is calculated based on the appropriateness of groundwater for irrigation consumption. WQI is distinguished as a score that indicates the combined influence of a number of water quality parameters. The computation of the WQI in groundwater studies began with Horton (1965) and Landwehr, Deininger, and Harkins (1974). According to Wu, Zhao, and Zhang (2010) selecting water quality metrics necessitates an assessment of the principal anthropogenic activity in the monitoring area. Domestic, agricultural, mining, and other anthropogenic activities may constitute the major anthropogenic activity. The groundwater quality index (GWQI) may be calculated by examining various significant factors and assigning a weight to each one.

1.1. Study Area

The Gadilam river rises in Kallakurichi district and flows through Viluppuram district before joining the Bay of Bengal in Cuddalore. This river has a total flow length of 102 kilometres and an area of 2091.20 square kilometres. According to reports, the river receives periodic floodwater from the Ponnaiyar River via the Malattat River. The basin of the Gadilam River stretches between 11°26'31.797" N to 11°56'29.633" N latitudes and 78°59'10.675" E to 79°47'15.793" E longitudes Figure 1.

It includes topographical maps 58I/13, 58M/1, 58M/2, 58M/5, 58M/6, 58M/7, 58M/9, 58M/10, 58M/11, and 58M/15 with a scale of 1:50,000. The research area is bounded to the north by Villupuram, to the east by Cuddalore town, to the west by Thirukoilur, and to the south by Vadalur. There are a total of 1024 tanks in the research region, with the majority (above 0.5 sq.km) including 62 tanks. Temperatures range from 38° to 39° C in April and May to 24° to 25° C in January and February. The wind velocity is greatest throughout the summer and, on occasion, during the monsoon season.

2. METHODOLOGY

The Gadilam River base border was defined using Survey of India topographical maps 58I/13, 58M/1, 58M/2, 58M/5, 58M/6, 58M/7, 58M/9, 58M/10, 58M/11, and 58M/15 on a 1:50,000 scale, as well as drainage updates in current satellite data. Landsat-8 TM data is used to create a spatial map of land use and land cover (March-2018). The geology map is derived from the district resources map. The upper basin of the Gadilam River reveals Archaean formation, while the lower basin displays Tertiary uplands in the south and recent alluvium (Quaternary) in the north Figure 1.

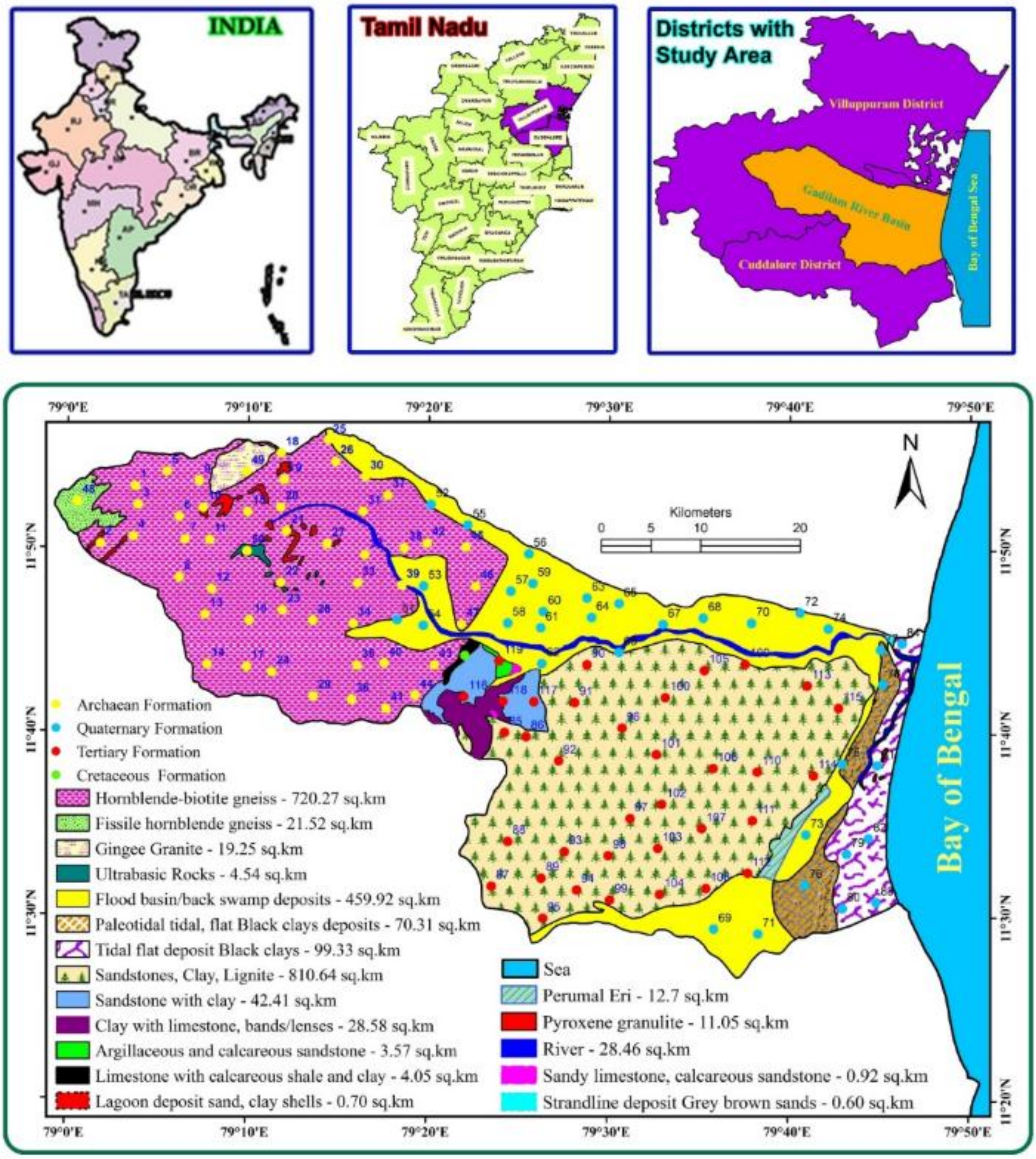

Figure-1. Key map of study area.

In all, 120 groundwater samples were taken from the Gadilam river basin, excluding the designated forest region. Figure 1 depicts the distribution of 50 samples obtained from the Archaean formation (Hornblende-biotite gneiss, Fissile hornblende gneiss, Gingee Granite and Ultrabasic Rocks). 34 Quaternary samples (Flood basin/back swamp deposits, Paleotidal tidal, flat Black clays deposits, Tidal flat deposit Black clays) and 35 Tertiary samples (Sandstones, Clay, Lignite, Sandstone with clay, Argillaceous). One sample from the Cretaceous formation. 1 litre plastic containers were used to collect groundwater samples. Groundwater samples collected during Nov. 2018, that was the time after the disastrous Gaja cyclone. It was a Category 4 Cyclonic Storm. Gaja was the sixth named storm in the North Indian Ocean in 2018.

The analysis of elements and parameters in the laboratory followed the standard methods. Each water sample from the collected samples was assessed for fourteen parameters such as TDS, TH, pH, EC, chloride, sulphate, sodium, magnesium, calcium, nitrate, potassium, sulphate, fluoride and bi-carbonate using standard-procedures of water test advised by the Federation and APHA (2005).

Groundwater quality index (GWQI) is calculated in accordance with the following equation.

$$GWQI = \frac{\sum_{i=1}^{n} W_1 \;\; q_1}{\sum_{i=1}^{n} W_1}$$

The quality rating is calculated according to the following equation.

$$q_{n1} = \frac{(V_{actual} \;\; V_{ideal})}{(V_{standard} \;\; V_{ideal})} X\ 100$$

where,

q_{ni} is the quality rating of the i^{th} parameter for the total (n) number of the water quality parameters.

V_{actual} is the measured value of water quality parameter (find from the laboratory).

V_{ideal} is the standard value of water quality parameter (find from standard tables).

The value of V_{ideal} for pH is 7 and for the other studied water quality parameters is zero.

3. RESULTS AND DISCUSSION

Table 1 displays the Archaean, Quaternary, and Tertiary formation lowest, maximum, average, and standard deviation values of physio-chemical parameters during November 2018 findings. During this season, the concentrations of Calcium (Ca2+), Magnesium (Mg2+), Nitrate (NO32-), Fluoride (F-), Sulphate (SO42-), Bi-carbonate (HCO3-), and Percentage of Hydrogen (pH) are all within the WHO 2011 limiting value.

Sodium (Na^+) values are found not permissible in some samples in Quaternary and Archaean formation due to concentrated colloids in water (Akhilesh & Dixit, 2008). All sample values are observed within limiting value for WHO 2011 in tertiary formation. The three formations sodium concentration shows that Quaternary formation is highest value (600 mg/L) and Archaean formation maximum value (250 mg/L) was noticed.

Potassium (K^+) and Total Hardness values are found not permissible in maximum samples in all the formations. But, the following sequence of high concentration Quaternary> Archaean> Tertiary. The three formations sodium and Total Hardness values shows that Quaternary formation is highest value of K (100 mg/L) and TH (704 mg/L), Archaean formation maximum value of K is 50 mg/L and TH value (684 mg/L) and Tertiary formation highest value of K (40 mg/L) and TH is 568 mg/L was noticed. High potassium values may cause nervous and digestive disorder (Ambrina & Srivastava, 2012). The highest values are due to the deeper depth of water level and high rate of evaporation during hot season (Mahmoud et al., 2016).

Chloride (Cl^-) and Total Alkalinity values are found not permissible in minimum number of samples only in Quaternary formation. The Chloride (Cl^-) and Total Alkalinity values shows that Quaternary formation is highest value of Cl^- (816 mg/l) and T.alk. (624 mg/L). Chloride (Cl^-) and Total Alkalinity values are observed within limiting value for WHO 2011 in Archaean and Tertiary formations during this season.

The EC values are found higher in some samples in all the formations. The three formations EC values shows that Quaternary formation is highest value (3400 µmohs/cm) and Archaean formation maximum value (2600 µmohs/cm) and Tertiary formations highest value is 1887 µmohs/cm was noticed. This may be due to concentrated colloids in water (Verma, Bushra, & Shruti, 2012).

Total Dissolved Solids (TDS) values are within limiting value for WHO 2011 in Tertiary formations during this season. Other two formations of some samples above limiting values was observed due to the common mineral salts that are dissolved in water (Al Dahaan, Al-Ansari, & Knutsson, 2016).

Table-1. Formation wise Statistical results of groundwater Physio-chemical Parameters.

Physio-Chemical Parameters	Desirable Values for WHO – 2011		Archaean – 50 Samples				Quaternary – 34 Samples				Tertiary – 35 Samples			
			November 2018											
	Most desirable limits	Maximum allowable limits	Min.	Max.	Ave.	Std. Dev.	Min.	Max.	Ave.	Std. Dev.	Min.	Max.	Ave.	Std. Dev.
Ca^{2+} (mg/L)	75	200	27.00	146.00	80.46	27.50	21.00	149.00	66.41	28.49	16.00	126.00	46.83	22.98
Mg^{2+} (mg/L)	50	150	12.00	77.00	42.36	15.47	6.00	80.00	33.88	16.05	7.00	60.00	22.34	11.68
Na^{+} (mg/L)	-	200	40.00	250.00	143.44	47.10	35.00	600.00	159.00	120.24	29.00	196.00	83.26	43.00
K^{+} (mg/L)	-	12	6.00	50.00	24.12	9.78	5.00	100.00	24.50	21.79	4.00	40.00	12.26	7.54
NO_3^{2-} (mg/L)	-	45	4.00	40.00	20.96	7.64	3.00	29.00	13.65	6.38	3.00	20.00	9.74	4.66
Cl^{-} (mg/L)	200	600	48.00	448.00	168.64	91.69	24.00	816.00	178.71	183.53	24.00	224.00	77.54	42.81
F^{-} (mg/L)	-	1.5	0.00	1.20	0.58	0.39	0.00	1.20	0.45	0.37	0.00	1.20	0.34	0.29
SO_4^{2-} (mg/L)	200	400	50.00	395.00	173.12	75.52	40.00	394.00	152.26	69.74	40.00	365.00	115.26	64.04
HCO_3^{-} (mg/L)	300	500	52.00	428.00	286.04	79.97	56.00	624.00	266.88	134.18	56.00	362.00	172.63	97.73
EC (µmohs/cm)	-	1500	454.00	2600.00	1448.70	469.13	372.00	3400.00	1377.74	740.66	288.00	1887.00	809.57	403.34
pH	6.5 – 8.5	9.2	7.12	8.12	7.51	0.28	7.17	8.05	7.44	0.23	7.21	8.21	7.52	0.25
TDS (mg/L)	500	1500	318.00	1820.00	1014.14	328.36	260.00	2380.00	964.15	518.80	202.00	1321.00	566.77	282.38
TH (mg/L)	100	500	116.00	684.00	377.64	132.97	88.00	704.00	307.06	137.64	72.00	568.00	210.51	105.79
T.Alk (mg/L)	-	500	52.00	428.00	286.04	79.97	56.00	624.00	266.88	134.18	56.00	362.00	172.63	97.73

3.1. Groundwater Quality Index

The formation wise water quality index for groundwater samples are tabulated in table 3. The values of groundwater water quality index demonstrate its appropriateness for irrigation uses. The WQI can classified into five types such as Excellent (<50), Good (51-100), Poor (101-150), Very poor (151-200) and Worst (>200).

The Archaean formation WQI values are found lesser than 100 in all stations in monsoon season. In order to WQI, these stations come under the category of **"Excellent" and "Good"** Table 2.

The Quaternary formation WQI values are observed lesser than 100 in all stations come under **"Excellent" and "Good"** except one station (Karikkuppam-83). In this 83th station is classified as "Poor" category for irrigation in monsoon season. But, all stations come under the category of **"Excellent" and "Good"** in summer season Table 2.

Table-2. Archaean formation water quality index.

Formations	WQI Values - November 2018	WQI Classes
Archaean formation	14.34 to 79.32	Excellent to Good
Quaternary formation	11.47 to 102.48	Excellent to Good (Except one sample 83th is Poor)
Tertiary formation	9.18 to 57.57	Excellent to Good

The Tertiary formation WQI values are less than 50 in all stations that come under **"Excellent"** except one station (Kalattur-119) which falls under **"Good"** in rainy season. But, 86 % of the stations come under the category of **"Excellent"** and the stations 93, 94, 97, 105, 109 are fall under **"Good"** in summer season Table 2.

4. CONCLUSION

Quaternary formation physio-chemical parameters are higher values noticed in rainy season due to the confined aquifer (Neyveli Aquifer) using fertilizer increasing agricultural activities. The groundwater quality parameters like Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Nitrate (NO_3^{2-}), Fluoride (F^-), Sulphate (SO_4^{2-}), Bi-carbonate (HCO_3^-) and Percentage of Hydrogen (pH) values are observed within limiting value for WHO 2011 in all the formations during this season.

The EC and TDS values are more than permissible limit for some stations in all the formations. The TH T.Alk values are seen exceeding limit for drinking purposes, 11 samples in Archaean formation. Quaternary formation was observed only 2 samples.

K values are seen exceeding limit for drinking purposes, 96 % of the samples in Archaean formation. Quaternary formation was observed only 74 % of the samples and 94 % of the samples are exceeding limit. The Cl, NO_3 values are seen exceeding limit for drinking purposes, none of the sample of Archaean and Tertiary formations. Quaternary formation was observed only two samples.

The Archaean, Quaternary and Tertiary formations WQI values are found lesser than 100 meq/L in all stations in monsoon season. With respect to WQI, these stations come under the category of **"Excellent" and "Good" for** irrigational uses.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Acknowledgement: Both authors contributed equally to the conception and design of the study.

REFERENCES

Akhilesh, J., & Dixit, S. (2008). Pre-and post-monsoon variation in physico-chemical characteristics in groundwater quality of Bhopal "The City of Lakes" India. *Asian Journal of Experimental Sciences*, *22*(3), 311-316.

Al Dahaan, S., Al-Ansari, N., & Knutsson, S. (2016). Influence of groundwater hypothetical salts on electrical conductivity total dissolved solids. *Engineering*, *8*(11), 823-830. Available at: https://doi.org/10.4236/eng.2016.811074.

Ambrina, K. S., & Srivastava, P. (2012). Physico-chemical characteristics of Ground water in and around Allahabad City: A statistical approach. *Bulletin of Environmental and scientific Research*, *1*(2), 28-32.

Brindha, K., Vaman, K. V. N., Srinivasan, K., Babu, M. S., & Elango, L. (2013). Identification of surface water-groundwater interaction by hydrogeochemical indicators and assessing its suitability for drinking and irrigational purposes in Chennai. *Southern India Applied Water Science*, *4*, 159-174. Available at: 10.1007/s13201-013-0138-6.

Brindha., K., & Kavitha, R. (2014). Hydrochemical assessment of surface water and groundwater quality along Uyyakondan channel. *South India Environmental Earth Sciences*, *73* 5383-5393. Available at: 10.1007/s12665-014-3793-5.

Federation, W. E., & APHA. (2005). *Standard methods for the examination of water and wastewater*. Washington, DC, USA: American Public Health Association (APHA).

Horton, R. K. (1965). An index number system for rating water quality. *Journal of Water Pollution Control Federation*, *37*(3), 300-306.

Kumar, S. K., Logeshkumaran, A., Magesh, N. S., Godson, P. S., & Chandrasekar, N. (2014). Hydro-geochemistry and application of water quality index (WQI) for groundwater quality assessment, Anna Nagar, part of Chennai City, Tamil Nadu, India. *Applied Water Science*, *5*(4), 335-343. Available at: 10.1007/s13201-014-0196-4.

Landwehr, J. M., Deininger, R. A., & Harkins, R. D. (1974). An objective water quality index. *Journal (Water Pollution Control Federation)*, *46*(7), 1804-1809.

Mahmoud, S., Shahub, M. S., Ibrahim, M. I., Algammal, M. A., Moktar, S., & Alatrash. (2016). Seasonal analysis of physico-chemical parameters of ground and surface water in Kaam area, Libya. *JESTFT*, *10*(6), 46-50.

Mishra, P. C., & Patel, R. K. (2001). Study of the pollution load in the drinking water of Rairangpur, a small tribal dominated town of North Orissa. *Indian International Journal of Environmental Science*, *5*(2), 293-298.

Naik, S., & Purohit, K. M. (2001). Studies on water quality of river Brahmani in Sundargarh district, Orissa. *Indian International Journal of Environmental Science*, *5*(2), 397-402.

Prasanna, M. V., Chidambaram, S., Hameed, A. S., & Srinivasamoorthy, K. (2011). Hydrogeochemical analysis and evaluation of groundwater quality in the Gadilam river basin, Tamil Nadu, India. *Journal of Earth System Science*, *120*(1), 85-98.

Rajesh, R., Brindha, K., & Elango, L. (2015). Groundwater quality and its hydrochemical characteristics in a shallow weathered rock aquifer of southern India. *Water Qual Expo Health*, *7*(4), 515–524.

Rina, K., Dutta, P. S., & Mukherjee, S. (2011). Characterization and Evaluation of processes governing the groundwater quality in parts of the Sabarmati basin. *Gujarat Using Hydrochemistry Integrated with GIS Hydrological Processes 26*, 1538-1551. Available at: 10.1002/hyp.8284.

Singh, C. K., Rina, K., Mallick, J., Singh, R., Singh, N., Shashtri, S., & Mukherjee, S. (2012a). Chemometric and GIS Based Analysis of Geogenic Augmentation of Fluoride in Groundwater of Arid Region of India. *International Journal of Environmental Protection, IJEP*, *2*(7), 24-29.

Singh, C. K., Rina, K., Singh, R. P., & Mukherjee, S. (2012b). Chemometric analysis to infer hydro-geochemical processes in a semi-arid region of India. *Arabian Journal of Geosciences*, *6*, 2915–2932. Available at: https://doi.org/10.1007/s12517-012-0597-3.

Singh, D. F. (1992). Studies on the water quality index of some major rivers of Pune, Maharashtra. *In Proc Acad Environ Biol*, *1*(1), 61-66.

Sonkamble, S., Sahya, A., Mondal, N. C., & Harikumar, P. (2012). Appraisal and evolution of hydrochemical processes from proximity basalt and granite areas of Deccan Volcanic Province (DVP) in India. *Journal of Hydrology, 438–439*, 181-193. Available at: https://doi.org/10.1016/j.jhydrol.2012.03.022.

Tiwari, T. N., & Nayak, S. (2002). Water quality index for the groundwater of Sambalpur Town. Environmental Pollution Research. New Delhi: APH Pub. Corp.

Verma, O. P., Bushra, K., & Shruti, S. (2012). Determination of physicochemical characteristics of four canals of Allahabad region and its suitability for irrigation. *Advances in Applied Science Research*, *3*(3), 1531-1537.

WHO. (2011). Guidelines for drinking water quality (4th ed., pp. 340). Geneva: World Health Organization.

Wu, Q., Zhao, C., & Zhang, Y. (2010). *Landscape river water quality assessment by nemerow pollution index*. Paper presented at the International Conference, IEEE. In Mechanic Automation and Control Engineering (MACE).