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RESEARCH ARTICLE

GROUNDWATER SUITABILITY ASSESSMENT: A CASE STUDY FROM YADAGIR DISTRICT, KARNATAKA STATE, INDIA

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Abstract

A total of 90 groundwater samples spread across three taluks of Yadagir district were collected during pre-monsoon season, 2018 and analyzed for physico-chemical parameters and irrigation quality parameters like sodium absorption ratio (SAR), Percent sodium (%Na) and residual sodium carbonate (RSC) were calculated to assess groundwater suitability for irrigation purpose. It was evident from the results that 8.82, 60 and 87.1 % of samples respectively in Yadagir, Shahapur and Shorapur taluks were recorded the pH values above the BIS standard limit of 6.5-8.5. Higher alkaline pH values prevailing in majority of groundwater samples from the study area is due to higher alkalinity and bicarbonate concentration. Electrical conductivity values in 35.29, 28 and 35.48 % of samples respectively in Yadagir, Shahapur and Shorapur taluks witnessed the higher values above 2000 µS/cm, while 97, 84 and 70.96 % samples respectively in the above taluks showed higher TDS values above BIS desirable limit of 500 mg/L. Overall quality of 32.22 % of groundwater samples from Yadagir district is classified as good water (50>WQI<100) based on WQI values and are considered as suitable for domestic and irrigation purpose. Rest of the samples were considered as unsuitable for domestic and irrigation purpose, attributed to higher salinity, total hardness, fluoride, TDS values, etc.

Introduction:-

Water from beneath the ground was being continuously exploited for domestic use, livestock and irrigation since from the earliest times. Exploitation of water from underneath the ground has been over-utilized for domestic use, irrigation and livestock since time immemorial. Although the precise nature of its occurrence was not necessarily understood, successful methods of bringing the water to the surface were developed and groundwater usage continued with greater extent (Chilton, 1996). Countries that contain more than half of the world's people are also dominantly groundwater dependent. These countries include the three big grain producers China, India and USA. Most of these countries are over pumping their groundwater to satisfy their growing water demands. Subsequently, the water quality situation is highly variable in many regions reflecting different levels of development (Somaya Abbaspour, 2011).

Naturally, ground water contains mineral ions which are slowly dissolve from soil particles, sediments, and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer. They are referred to as dissolved solids, where as some dissolved solids may have originated in the precipitation water or river

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water that recharges the aquifer. Groundwater quality in a region is largely determined by both natural processes (dissolution and precipitation of minerals, groundwater velocity, quality of recharge water, and interaction with other types of water aquifer) and anthropogenic activities, water quality is depend upon the type of the pollutant added and the nature of mineral found at particular zone of vertical section (Devendra Dohare et al., 2014). The combinations of these factors create diverse water types that change groundwater characteristics spatially and temporally (Gholami, et al., 2009 and Praveena, et al., 2011) in addition to land use change and land cover (Mapani, 2005; Zhang, and Schilling, 2006; Held, et al., 2007; Jat, et al., 2009 and Lerner, and Harris, 2009). This complexity of ground water can be understand by using WQI which can transform large amount of water quality data into a single number represents the water quality level as noticed by many studies (Tiwari, and Mishra, 1985; Debels, et al., 2005; Sandow Mark et al., 2010 and Vasanthavigar, et al., 2010). The assessment of groundwater resource and the analysis of hydro chemical properties of groundwater in specific region are having significant applications (Senthilkumar, and Meenambal, 2007; Kulandaivel, et al., 2009 and Fatombi, et al., 2012). Therefore the study was performed to assess the groundwater suitability through a water quality index.

Material and Methods:-

Study Area:

Yadgir District is the 2nd smallest district in Karnataka state, which was carved out from the erstwhile Kalburgi district as the 30th district of Karnataka. Geographically, the district is spread between $16^0 11' - 16^0 50'$ N latitudes and $76^0 17' - 77^0 28'$ E longitudes, with a geographical area of 5234.4 Sq.Km. It is located in the North-eastern part of Karnataka state and is surrounded by Kalburgi (Gulbarga) district in the North, Raichur district in the South, Vijayapur (Bijapur) district in the West and the state of Telengana in the East. The district comprises of 3 taluks namely, Shahapur, Yadgiri and Shorapur (Figure 1). There are16 hoblies, 117 Gram Panchayats, 4 Municipalities,8 Towns/ Urban agglomeration and 487 inhabited and 32 un-inhabited villages. Population of the district (2011 Census) is 1172985 with an average population density of 224 per km^2.

Yadgir district lies in the northern plains of Karnataka and has semi - arid type of climate. Yadgir district is predominantly an agricultural district divided into two agro-climatic zones namely eastern transition and north eastern dry zone as the climate is generally hot, dry and healthy. Hence, the zones indicate the predominance of rain dependent dry land agricultural area and dry climate prevails for most part of the year. December is the coldest month with mean daily maximum and minimum temperatures being 29.5^0 C and 15^0 to 10^0 C respectively. During peak summer, temperature shoots up to 45^0 C. Relative humidity varies from 26% in summer to 62% in winter. The southwest monsoon sets in the middle of June and extends till the end of September. Bulk of the annual rainfall occurs during this season, which constitutes over 77% of the annual rainfall. Significant rainfall occurs during the winter monsoon owing to north eastern monsoon, which constitutes 7% of the annual rainfall. Normal Rainfall of the district is 699 mm (2001 - 2010) and actual rainfall is 633 mm during 2011 (CGWB, 2012).

The northern part of the district represents a plateau, typical of Deccan Trap terrain and is deeply indented with ravines. The southern part represents undulating terrain with sparsely distributed knolls and tors. The southern part of the district comprises the Peninsular Gneiss and granites. Central, northeastern and southwestern part comprises of sedimentary formations viz. sandstone, quartzite, shale, slate, limestone and dolomite. Deccan Trap basalts cover eastern parts. Major ground water bearing formations are granite, gneiss, limestone and vesicular basalt. Ground water occurs in weathered, fractured and jointed zones of these formations (CGWB, 2012). In weathered zones ground water occurs in phreatic condition, whereas in the fractured and jointed formation it occurs in semi-confined to confined condition. A small portion of Deccan Trap basalts, which comprise different flows, fractures & interstitial pore spaces of vesicular zone, are good repositories of ground water. In limestone, solution cavities are considered to be more potential than weathered and fractured zones. Laterite have primary porosity and are considered to be moderately good aquifer. The main source of recharge to ground water is precipitation, followed by seepage from canals and return flow from irrigation.

About 75% of the geographical area of the district is under cultivation. Both Shahapur and Surpur (Shorapur) taluks have been fully irrigational land, while Yadagir Taluka having 65% irrigated area. Agriculture in the district mainly depends upon the rainfall and the net area irrigated to net area sown is 14%, which is below the state average of 24%. Yadgir has been blessed by the incessant flowing of two main rivers, “Krishna’ and ‘Bhima’ along with few tributaries. Kagna and Amarja are the two sub-basins of Bhima River, which occur within the geographical area of the district. Irrigation through dug wells is more prevalent in Yadgir taluk, whereas, irrigation in Shorapur and Shahpur taluks is through canal of Upper Krishna Project. Lift Irrigation Schemes are under implementation along

Bhima River. The major crops grown in the district are jowar, paddy, red gram, sunflower, groundnut, cotton and Sugarcane. In terms of productivity the yields of principal crops is lesser than the state average. The variation in rainfall and endemic pest attack has affected productivity of tur (red gram). The production and productivity of jowar has been improving because of better use of fertilizer and plant protection measures. In case of oil seeds the area and production has been decreased.

Methodology:-

A total of 90 groundwater samples spread across three taluks of Yadagir district **(Fig 1)** were collected during February / March 2018. Parameters such as pH, electrical conductivity, TDS were analyzed in the field, while remaining parameters were analyzed after transporting the collected samples to laboratory following recommended standard methods of storage and transportation (APHA, 2012). Before collecting the groundwater samples, the bore / hand pumps were operated for 10 mins to ensuring the collection of representative sample. Based on the physico-chemical analyses, irrigation quality parameters like sodium absorption ratio (SAR), Percent sodium (%Na) and residual sodium carbonate (RSC) were calculated to assess groundwater suitability for irrigation purpose. Overall groundwater quality was evaluated by calculating water quality index (WQI) followed the methodology described elsewhere (BIS, 2003; WHO, 2011 and Ravikumar, et al., 2015).

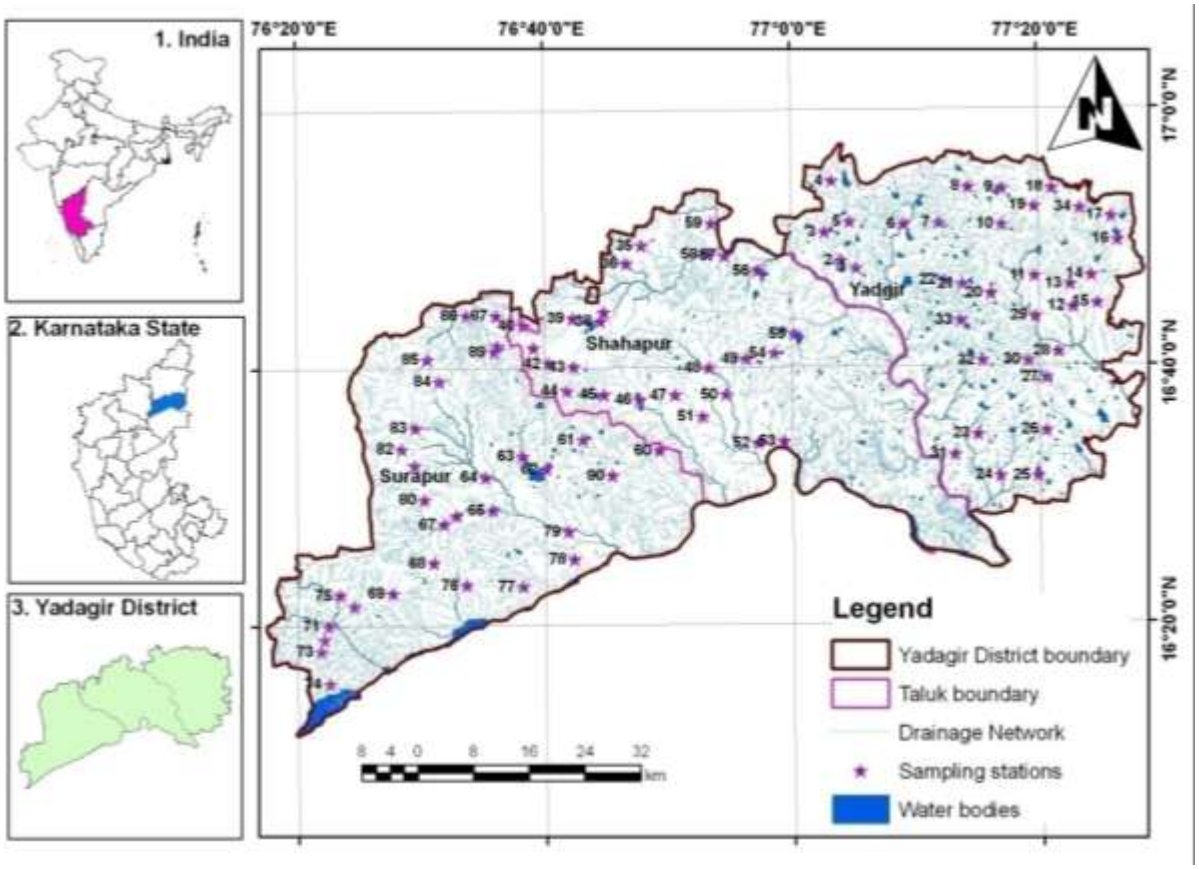

Fig 1:- Study area map showing location of sampling stations.

Results and Discussion:-

The Analytical results of the physico-chemical parameters, irrigational quality parameters and WQI for the groundwater samples analyzed are given in **Table 1**.

Table 1:- Descriptive statistics showing analytical results for groundwater samples.

Parameters	Yadgir (n=34)			Shahapur(n=25)			Surpur(n=31)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
pH	7.50	8.90	8.10	7.70	9.30	8.50	8.30	9.50	8.90

EC	575.0	5670.0	1974.7	710.0	10520.0	2376.4	630.0	3380.0	1700.0
TDS	368.0	3628.8	1263.8	360.0	5250.0	1187.6	310.0	1680.0	847.4
Hardness	140.0	1150.0	460.6	170.0	2220.0	609.2	140.0	880.0	453.8
Ca^{2+}	28.0	344.0	103.5	24.0	609.0	131.9	40.0	232.0	102.6
Mg^{2+}	17.1	156.2	49.2	10.0	321.0	69.0	5.0	124.0	47.9
Alkalinity	52.0	520.0	239.3	211.0	1204.0	447.1	215.0	699.0	420.1
Na^{+}	30.9	470.8	142.6	50.0	2172.0	338.7	42.7	512.0	198.2
K^{+}	0.3	126.5	13.3	1.1	144.0	27.5	2.2	337.0	28.8
Cl^{-}	20.0	1089.7	230.2	52.0	2084.0	391.8	87.0	588.0	222.2
SO_4^{2-}	21.0	368.0	165.9	31.1	2026.0	280.1	51.2	697.0	210.4
F^{-}	0.6	2.3	1.2	0.3	4.8	1.4	0.2	3.1	1.0
PO_4^{3-}	0.1	0.7	0.2	0.0	0.6	0.2	0.0	0.3	0.2
HCO_3^{-}	63.4	634.4	292.0	257.0	1469.0	545.4	262.0	852.0	512.4
SAR	0.85	17.30	3.21	1.01	19.95	5.04	1.01	13.49	4.22
% Sodium	15.23	87.94	38.66	18.02	77.09	43.76	18.98	82.84	42.70
RSC	-18.26	8.99	-1.25	-35.42	19.72	2.63	-4.17	19.74	4.93
WQI	63.80	313.08	141.50	58.58	723.34	187.18	62.57	389.62	142.94

It was evident from results that 8.82, 60 and 87.1 % of samples respectively in Yadagir, Shahapur and Shorapur taluks recorded pH values above the BIS standard limit of 6.5-8.5(Fig 2).

The higher alkaline pH values prevailing in majority of groundwater samples from the study area is due to higher alkalinity concentration as its concentration in 47, 100 and 100 % samples from Yadagir, Shahapur and Shorapur taluks were above BIS desirable limit of 200 mg/L. Similar trend was observed with bicarbonate concentration as 41.2, 96 and 96.8 % samples showed higher values above 300 mg/L, Similarly, 61.76, 80 and 83.87 % of the groundwater samples from Yadagir, Shahapur and Shorapur taluks were very hard in nature as their total hardness values were above 300 mg/L.

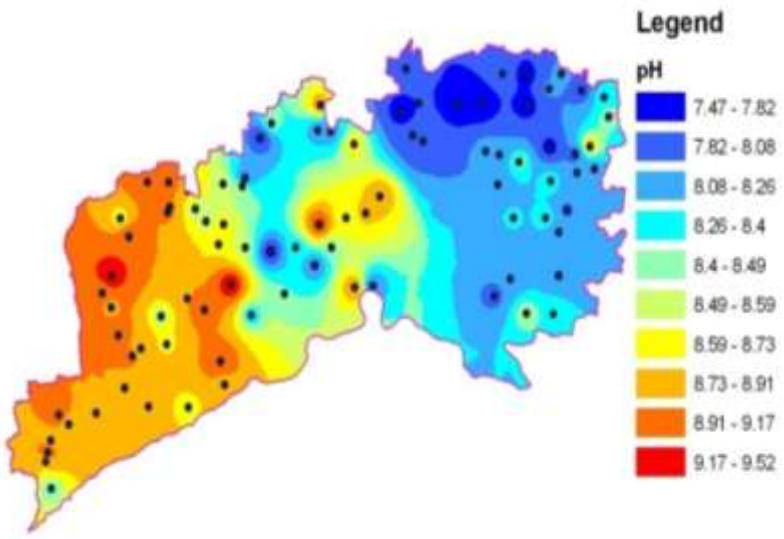

Fig 2:- Spatial distribution of pH values in the study area.

Electrical conductivity values are 35.29, 28 and 35.48 % of samples respectively in Yadagir, Shahapur and Shorapur taluks witnessed higher values above 2000 µS/cm (Fig 3). The higher level of EC value in water not suitable for drinking purpose but also E.C values more than 700 µS/cm are unsuitable for irrigation purposes (Handa, 1969), while 97, 84 and 70.96 % samples respectively in the above taluks showed higher TDS values above BIS desirable limit of 500 mg/L(Fig 4).

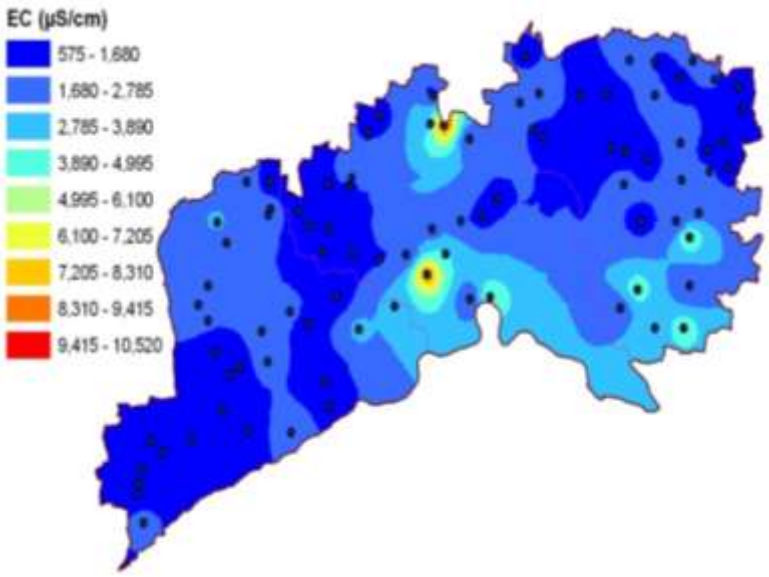

Fig 3:- Spatial distribution of Electrical Conductivity in the study area.

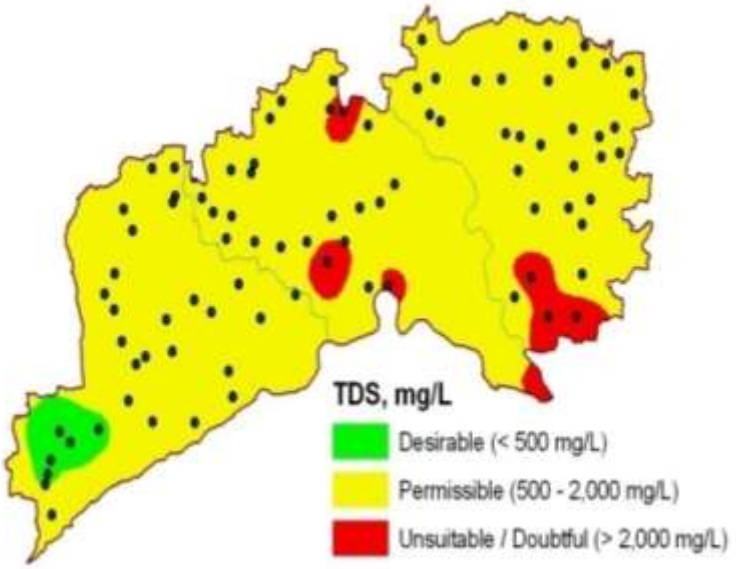

Fig 4: Spatial distribution of Total dissolved solids in the study area.

Calcium concentration in 50, 60 and 83.87 % of groundwater samples from taluks in similar order exceeded BIS desirable limit of 75 mg/L, the High concentration of Calcium (>200mg/L) are mainly related to agricultural areas (Bathrellos, et al., 2008), while 64.7, 28 and 70.96 % samples from taluks in same order showed magnesium values above BIS desirable limit of 30 mg/L. This high magnesium values in groundwater samples, which might have been derived from dissolution of magnesium calcite, gypsum and dolomite from source rock (Garrels and Christ, 1965). The high concentration of magnesium reduces the soil quality, the crops yield as well as it gives toxicity when it exceeds 50% of magnesium ratio (Ramkumar, et al., 2013). On the other hand, sodium values in 20.6, 40 and 38.7% of samples from Yadagir, Shahapur and Shorapur taluks was above 200 mg/L while potassium values was higher than 10 mg/L in 17.65, 48 and 67.7 % of samples from Yadagir, Shahapur and Shorapur taluks. Very high fluoride values above BIS standard limit of 1.5 mg/L was observed in some samples as revealed by percentage of samples (viz., 29.4, 28 and 25.8 % of samples from Yadagir, Shahapur and Shorapur taluks) showing higher values **(Fig 5)**. The similar trend was observed in the ground waters of Uttar Pradesh (Manjesh Kumar and Ramesh Kumar, 2013).

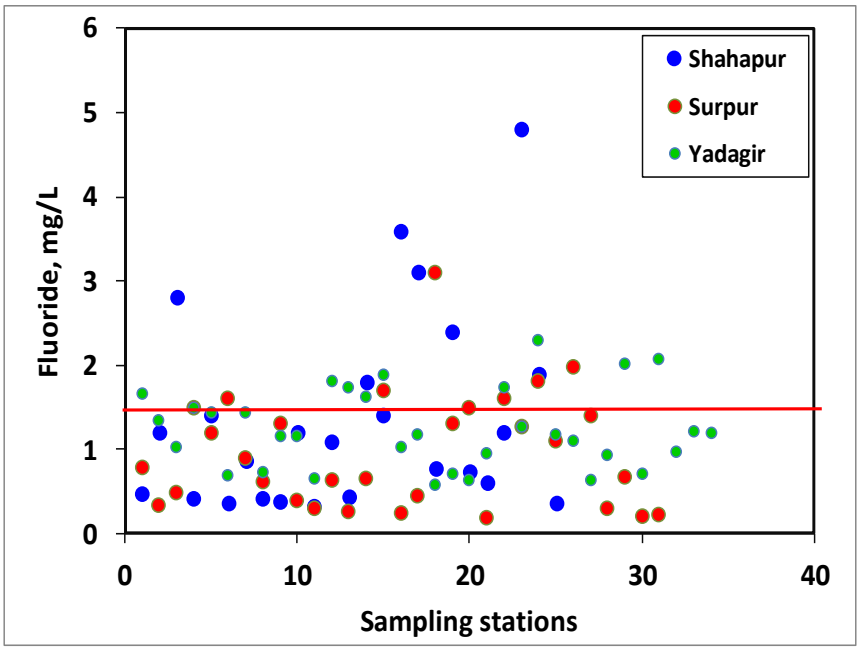

Fig 5:- Spatial distribution of Fluoride in the study area.

The large spatial variation of chloride concentration with maximum value of 1089.7, 2084 and 588mg/L was noticed in Yadagir, Shahapur and Shorapur taluks respectively, indicates recharge and discharge zones of lateral flow regime as local recharge to the unconfined aquifer (Datta, and Tyagi, 1996 and Kumar, 2009) and also the chloride content increases with increase in mineral content (Magesh and Chandrasekar, 2013).

Groundwater suitability assessment:-

Irrigational quality parameters suggested that majority of samples could be used for irrigation purpose in the study area; provided there is proper drainage capacity is ensured. This is because some samples were categorized as unsuitable for irrigation purpose based on SAR, percent sodium and RSC values. In the study area, only 8 % samples from Shahapur taluk recorded SAR values above 18 mg/L and is unsuitable for irrigation purpose. Rest all samples are categorized as suitable for irrigation. Similarly, 34.3, 56 and 45.2 % of samples from Yadagir, Shahapur and Shorapur taluks were recorded higher percent sodium values above 40, illustrating their unsuitability for irrigation. RSC values also illustrated unsuitability of some samples for irrigation purpose as its value in 44.1, 72 and 80.6% of samples from taluks in same order exceeded 1.25 meq/L. Overall groundwater quality in the study area was also evaluated by calculating WQI values. Accordingly, 32, 36 and 29 % of groundwater samples from Yadagir, Shahapur and Shorapur taluks were classified as good water (50>WQI<100) and are considered as suitable for domestic and irrigation purpose (Fig 6). Rest of the samples belong to either poor water (100>WQI<200), very poor water (200>WQI<300) and water unsuitable for drinking (WQI > 300).

Conclusion:-

It was evident from the results that 8.82, 60 and 87.1 % of samples respectively in Yadagir, Shahapur and Shorapur taluks were recorded the pH values above the BIS standard limit of 6.5-8.5. Higher alkaline pH values prevailing in majority of groundwater samples from the study area is due to higher alkalinity and bicarbonate concentration. Electrical conductivity values in 35.29, 28 and 35.48 % of samples respectively in Yadagir, Shahapur and Shorapur taluks witnessed the higher values above 2000 µS/cm, while 97, 84 and 70.96 % samples respectively in the above taluks showed higher TDS values above BIS desirable limit of 500 mg/L.

Irrigational quality parameters (viz., SAR, Percent sodium and RSC) suggested that majority of samples could be used for irrigation purpose in the study area, provided the proper drainage capacity is ensured. Overall quality of 32.22 % of groundwater samples from Yadagir district was classified as good water (50>WQI<100) based on WQI values and are considered as suitable for domestic and irrigation purpose. Rest of the samples are considered as unsuitable for domestic and irrigation purpose, attributed to higher salinity, total hardness, fluoride, TDS values, etc.

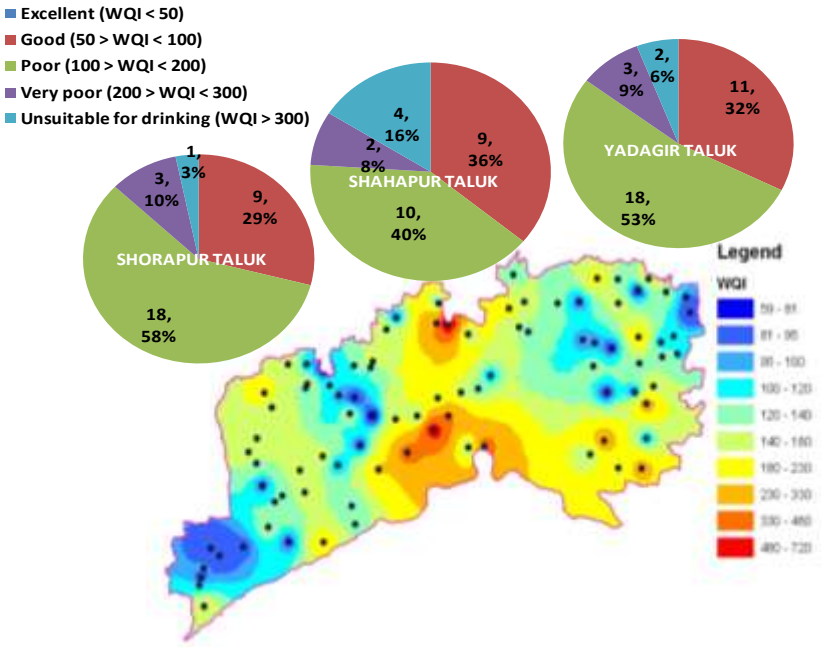

Fig 6:- Distribution of WQI in the groundwater samples from study area.

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References:-

1. Chilton, J. (1996). Groundwater. In: D. Chapman [Ed.] Water Quality Assessments. A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring. 2nd edition. Chapman and Hall, London.
2. Somaya Abbaspour. (2011). Water Quality in Developing Countries, South Asia, South Africa, Water Quality Management and Activities that Cause Water Pollution. IPCBEE, 15: 94-102.
3. Devendra Dohare, Shriram Deshpande and Atul Kotiya. (2014). Analysis of Ground Water
4. Quality Parameters: A Review, Research Journal of Engineering Sciences, 3(5): 26-31.
5. Gholami, V., Yousef, Z. and Rostami, H. Z. (2009). Modeling of groundwater salinity on the Caspian southern Coasts. Water Resource Management, 24:1415-1424.
6. Praveena, S. M., Abdullah, M. H., Bidin, K. and Aris, A. Z. (2011). Understanding of groundwater salinity using statistical modeling in a small tropical island, East Malaysia. Environmentalist, 31:279-287.
7. Mapani, B. S. (2005). Groundwater and urbanization, risk and mitigation: the case for the city of Windhoek, Namibia. Physics and Chemistry of Earth, 30:706-711.
8. Zhang, Y. K. and Schilling, K. E. (2006). Effects of land cover on water table, soil moisture, Evapo-transpiration and groundwater recharge: A field observation and analysis. Journal of Hydrology, 319(1):328-338.
9. Held, I., Wolf, L., Eiswirth, M. and Hotzl, H. (2007). Impacts of sewer leakages on groundwater. In: Tellam, J. H, Rivett, M. O., Israfilov, R. G., Herringshaw, L. G. (eds) NATO book series, Urban groundwater management and sustainability, 74:189-204.
10. Jat, M. K., Khare, D. and Garg, P. K. (2009). Urbanization and its impact on groundwater: a remote sensing and GIS-based assessment approach. Environmentalist, 29:17-32.
11. Lerner, D. N. and Harris, B. (2009). The relationship between land use and groundwater resources and quality. Land Use Policy, 26S, S265-S273.
12. Tiwari, T.N and Mishra, M (1985). A preliminary assignment of water quality index of major Indian rivers. Indian J. Environ Prot, 5:276-279.
13. Debels, P, Figueros, R, Urrutia R, Barra R, Niell X (2005). Evaluation of water quality in the Chillan river (Central Chile) using physic-chemical parameters and a modified water quality index. Environ. Monit. Assess, 110: 301 322.

14. Sandow Mark Yidana Æ Adadow Yidana. (2010). Assessing water quality using water quality index and multivariate analysis. Environ Earth Sci, 59:1461–1473.
15. Vasanthavigar M, Srinivasamoorthy, K, Vijayaraghavan, K, , Rajiv Gandhi, R, Chidambaram, S, Anandhan, P, Manivannan, R, Vasudevan. S. (2010). Application of water quality index for ground water quality assessment: Thirumanimuttar sub-urban, Tamilnadu, India. J. Environ Monit Assess, 171:595 – 609.
16. Senthilkumar, S and T. Meenambal. (2007). Study of ground water quality near Sipcot industrial estate of Perundurai of Erode district, Tamilnadu. Nat. Environ. Pollut. Technol, 6:741 – 744.
17. Kulandaivel, A.R.K., P.E. Kumar, V. Perumal and P.N. Magudeswaran. (2009). Water quality index of river Cauvery at Erode region, Tamilnadu, India. Nat. Environ. Pollut. Technol, 8:343 – 346.
18. Fatombi, J.K., A. T. Ahoyo., O.Nonfodji and T. Aminou. (2012). Physico-chemical and bacterial charecteristics of ground water and surface water quality in the Lagbe town: Treatment essays with Moringa Oleifera seeds. Water Res. Protect. 4: 1001 -1008.
19. CGWB. Ground Water Year Book of Karnataka, GOI, (2012).
20. APHA. (2012). Standard Methods for the examination of water and waste water, 22nd Edition, Washington: American Public health Association.
21. BIS (2003). Indian Standard Drinking Water Specifications (IS 10500:1991), Ed. 2.2 (2003-2009), Bureau of Indian Standard, New Delhi.
22. WHO. (2011). Guidelines for Drinking Water Quality. 4th Edition, World Health Organization, Geneva.
23. Ravikumar, P, Somashekar, R.K and Prakash, K.L. 2015. A comparative study on usage of Durov and Piper diagrams to interpret hydro-chemical processes in groundwater from SRLIS river basin, Karnataka, India. Elixir Earth Sci. 80:31073-31077
24. Handa, B.K., (1969). Description and classification of media for hydro-geochemical investigations. Symposium on Ground Water Studies in Arid and Semiarid Regions, Roorkee, India.
25. Bathrellos, G. D., Skilodimou, H. D., Kelepertsis, A., Alexakis, D., Chrisanthaki, I. and Archonti, D. (2008). Environmental research on groundwater in the urban and suburban areas of Attica region, Greece. Environmental Geology, 56:11-18.
26. Garrels, R. M. and Christ, C. L. (1965). Solutions minerals and equilibria. New York: Harper and Row, 450.
27. Ramkumar, T., S. Venkatramanan, I. Anithamary and S.M.S. Ibrahim, (2013). Evaluation of hydro-geochemical parameters and quality assessment of the groundwater in Kottur blocks, Tiruvarur district, Tamilnadu, India. Arab. J. Geosci., 6:101-108.
28. Manjesh Kumar and Ramesh Kumar, (2013). Assessment of Physico-Chemical properties of Ground Water in granite mining area in Goramachia, Jhansi (India), 2(1): 19-24.
29. Datta, P. S. and Tyagi, S. K. (1996). Major ion chemistry of groundwater in Delhi area, India. Journal of Geological Society of India, 47:179-188.
30. Kumar, M. Sharma, B., Ramanathan, A. L., Rao, M. S. and Kumar, B. (2009). Nutrient chemistry and salinity mapping of the Delhi aquifer, India: source identification perspective. Environmental Geology, 56:1171-1181.
31. Magesh, N. S. and Chandrasekar, N. (2013). Evaluation of spatial variations in groundwater quality by WQI and GIS technique: a case study of Virudunagar District, Tamil Nadu, India. Arabian Journal of Geosciences, 6(6):1883-1898.