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Water quality index over the decades in Krishnagiri district by using GIS

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Abstract
Groundwater is an important source for drinking water especially in rural areas. The lack of clean drinking water is advising affecting the general health and life expectance of the people in many developing countries. India with declining fresh water resources has an acute shortage of potable water of acceptable quality. In Krishnagiri Groundwater from phreatic aquifers is colorless, odorless and predominantly alkaline in nature. Water quality data of 82 observation wells for 38 years (1975 to 2013) was collected from the office of State Surface & Ground Water Data Centre, Public Works Department, Taramani, Chennai, Tamil Nadu and analyzed. Based on these data, the hydrological parameters of the study area was estimated and water quality index map was prepared to assess the suitability of drinking water. It is observed that the ground water is suitable for drinking and domestic uses in respect of all the constituents except total hardness, fluoride and nitrate in about 67.85 and 50% of the samples. Total hardness as CaCO3 is observed to be in excess of permissible limits in 33% of the samples analyzed, whereas nitrate is found in excess of 45 mg/l in about 50% of samples. Excess fluoride more than the permissible limit of 1.5 mg/l is observed at K.Vetrapatti and Karukanchavadi areas. The incidence of high total hardness is attributed to the composition of litho-units constituting the aquifers in the district, whereas nitrate pollution is most likely due to the use of fertilizers and other improper waste disposal.

Keywords: Water quality index, permissible limits, Geographical index system, pre and post monsoon and groundwater

Introduction
Groundwater from different parts of the country indicate that over exploitation of resources led to significant consequences such as lowering of groundwater table, increase in depth of all types of soil, widening of variable in water levels between rainy and non-rainy seasons, increase in pumping hours, low efficiency of agricultural pump sets, failure of wells, reduction in life of wells, large variability in production of crops, decline in area commanded by wells, emergence of groundwater markets, deterioration of quality of water, wee deepening and drilling new bore wells. These consequences are affecting equity, efficiency and sustainability of both groundwater use and agricultural production.

In addition to over exploitation and water level decline, deterioration of quality of water is a major concern in several regions of India. Nowadays, dumping of industrial and domestic waste pose serious threat to groundwater quality and may reduce the water availability for irrigation, domestic and industrial uses. Quality of groundwater is equally important to its quantity owing to the suitability of water to various purposes. Variation of groundwater quality in an area is a function of physico-chemical parameters that are generally influenced by geological formations and anthropogenic activities.

In view of the above circumstances groundwater quality analysis, physico-chemical parameters are to be studied for accessing the water quality and interpreted using GIS. There are different ways for accessing water quality; one among is Water Quality Index (WQI). WQI is an efficient tool on communicating the overall quality of water. WQI provides a single number that expresses overall water quality at certain location, based on several water quality parameters. And it integrates complex data to score that describes the status of water quality to the public as well as decision and policy makers. Moreover, it may be used for comparing the quality of different water sources and in monitoring the temporal changes in the quality of water. It reflects the aggregate influence of various physical, chemical and biological parameters of water quality conditions. The results of the WQI allow the preliminary classification of groundwater for the purpose of various uses and provide a benchmark for evaluating management strategies. Hence this study was undertaken to determine the water quality index over the decades in different parts of Krishnagiri district in Tamil Nadu.

Materials and methods

Krishnagiri district is bounded by Vellore and Thiruvannamalai districts in the East, Karnataka state in the west, State of Andhra Pradesh in the North, Dharmapuri District in the south. Its area is 5143 Sq. Kms. This district is elevated from 300m to 1400m above the mean sea level. It is located between 11º 12' N to 12º 49' N Latitude, 77º 27' E to 78º 38' E Longitude.

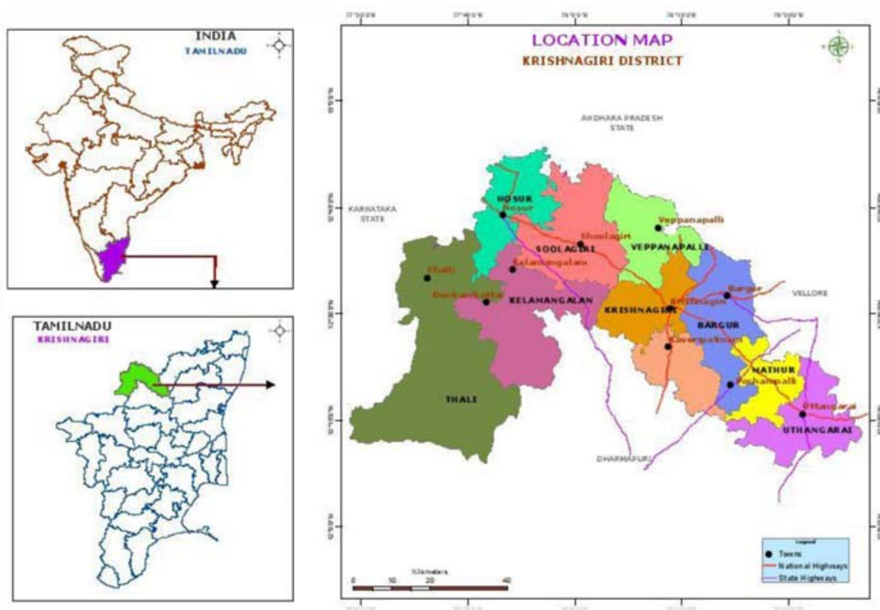

Fig 1: Location Map of Krishnagiri District (study area)

Estimation of Water Quality Index

WQI is computed to reduce the large amount of water quality data to a single numerical value. It reflects the composite influence of different water quality parameters on the overall quality of water. It is a very useful tool for communicating the information on the overall quality of water. The weighted arithmetic mean function has been used to determine the groundwater quality index. The weighted arithmetic mean function is ambiguity free function, shows small eclipsing with large number of variables and is widely used aggregation function. The formula used to determine the aggregated water quality index is

$$WQI = \sum_{i=1}^{n} W_i q_i / W_i$$

Where, W_i= Weightage factor computed using

$$W_i = K/S_i$$

Where,
S_i = Standard value of i^{th} water quality parameter
K = proportionality constant, which is taken as 1.0
n = the total number of water quality parameters
Quality rating (q_i) is computed using

$$q_i = \{[(v_a - v_i)/(S_i - v_i)] \times 100\}$$

Where,
q_i= Quality rating for the i^{th}water quality parameter
v_a= Actual value of the i^{th}water quality parameter
v_i = Ideal value of the i^{th}water quality parameter

Based on the obtained WQI values, the groundwater quality is rated as excellent, good, poor very poor and unfit for human consumption.

Table 1: Status of Water Based on WQI

S. No.	Water Quality Index	Status
1	0-25	Unfit For Drinking
2	26-50	Very Poor (Moderately Polluted)
3	51-75	Poor
4	76-100	Good
5	>100	Excellent

Spatial distribution of physio-chemical parameters by using GIS

Groundwater is an important source for drinking water especially in rural areas. The lack of clean drinking water is advising affecting the general health and life expectance of the people in many developing countries. The rapid growth rates of population, industry and agricultural practices has not only increased the exploitation of groundwater but have also contributed towards the deterioration of its quality. Therefore, the preservation and improvement of groundwater quality is of vital importance for human wellbeing as well as for the sustainability of clean environment.

Spatial analysis module in ArcGIS software has been used for the present study. Spatial analysis of drinking water quality was carried out by interpolation of sampling points by the algorithmic method ‘Industrial Distance Weighted’(IDW).The location of the sampling stations were imported into GIS software as point layer. Each sample point was assigned by a number and stored in the point attribute table. The attribute data file contains values of all physio-chemical parameters in separate columns for each sampling station. The geo database was used to generate the spatial distribution map of the analysed water quality parameters like pH, Electrical Conductivity, Total Dissolved Solids (TDS), chloride, sulphate, calcium, magnesium, fluoride, bicarbonate, Total Hardness, nitrate for pre and post monsoon and the results were given.

Results and discussion

pH

pH is defined as the negative logarithm of hydrogen ion concentration present in water and is an indicator of the acidity or alkalinity of water. The permissible limit of pH recommended for public water supplies is 6.5 to 8.5. pH value varies in the study area from 7.2 to 9.2 during pre-monsoon season while in post-monsoon it ranges between 7.1 to 8.8. The average value of pre and post-monsoon values are 8.25 and 8.05 which means the value doesn’t exceed the maximum permissible limit during both seasons. Taste of the water will be affected if pH value increase or decrease in the water. Decadal summary results showed that pH values are in fluctuating trends in both pre and post monsoon periods. The spatial distributions of pH concentrations map for pre-monsoon and post-monsoon are shown in the figures. This shows that the groundwater in the study area is slightly alkaline in nature and is between the maximum permissible limits of WHO standards. The slight alkalinity may be due to the presence of bicarbonate ions, which are produced by the free combination of CO_2 with water to form carbonic acid, which affects the pH of the water.

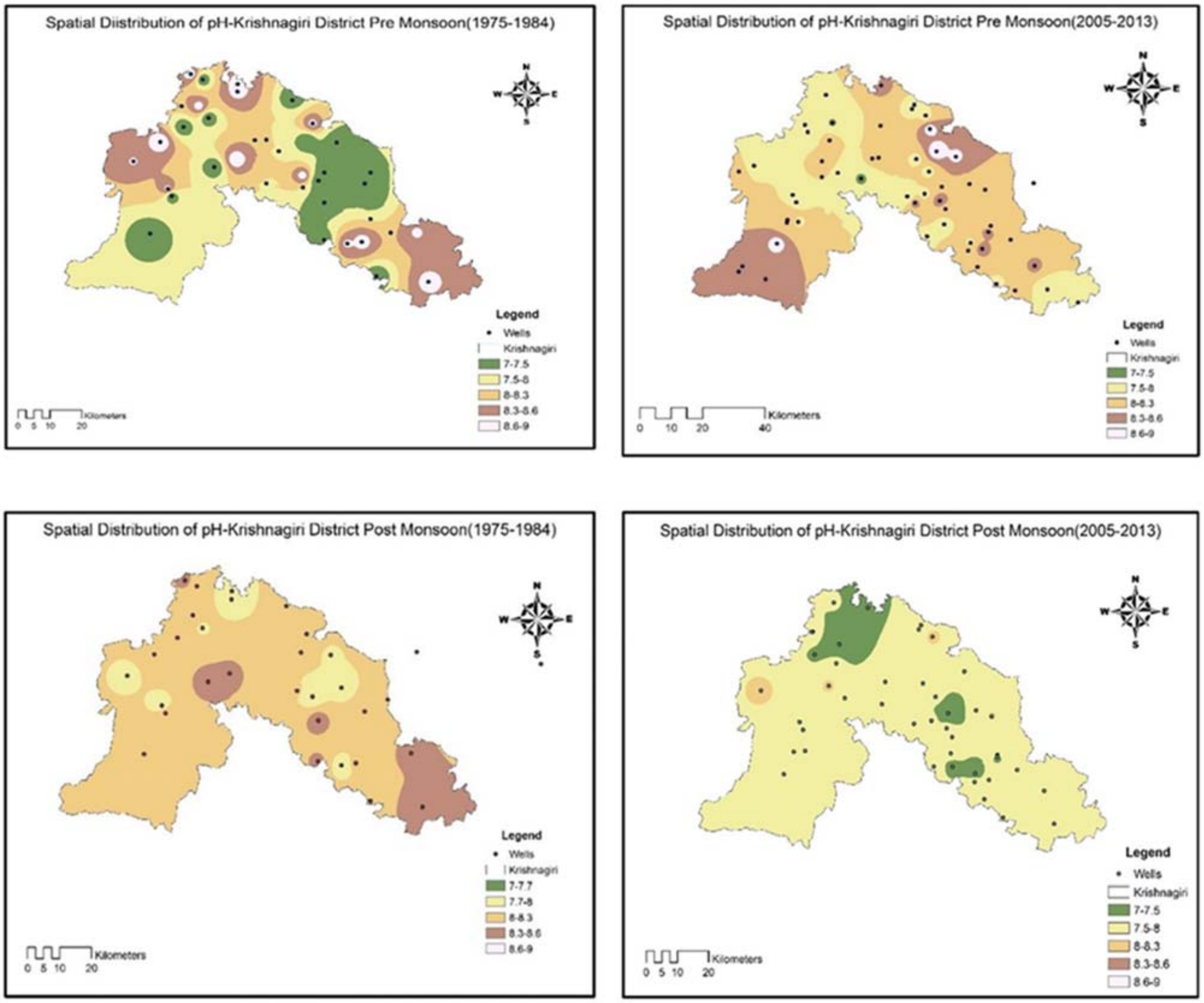

Fig 2: Spatial distribution of pH over Krishnagiri district (pre and post monsoon)

Electric Conductivity

Electric conductivity is the ability of water to allow electric current through it and is expressed in micro mhos per centimeter (mhos/cm). Conductivity value of fresh waters is in the range of 5-500 micro mhos/cm. The EC values ranged from 74 to 7574 during pre-monsoon and 100.67 to 4918.57 during post monsoon micro mhos/cm at 25 deg Celsius, respectively. The mean value of Electrical conductivity in pre and post monsoon is 2163.73 and 1571.68 micro mhos/cm. Decadal variation of EC showed that the EC value was increasing trend in post-monsoon period. The higher values of EC are due to discharge of untreated wastewater, infiltration, mining and agricultural runoff and also due to long residence time and existing lithology of the region (Ballukraya and Ravi, 1999).

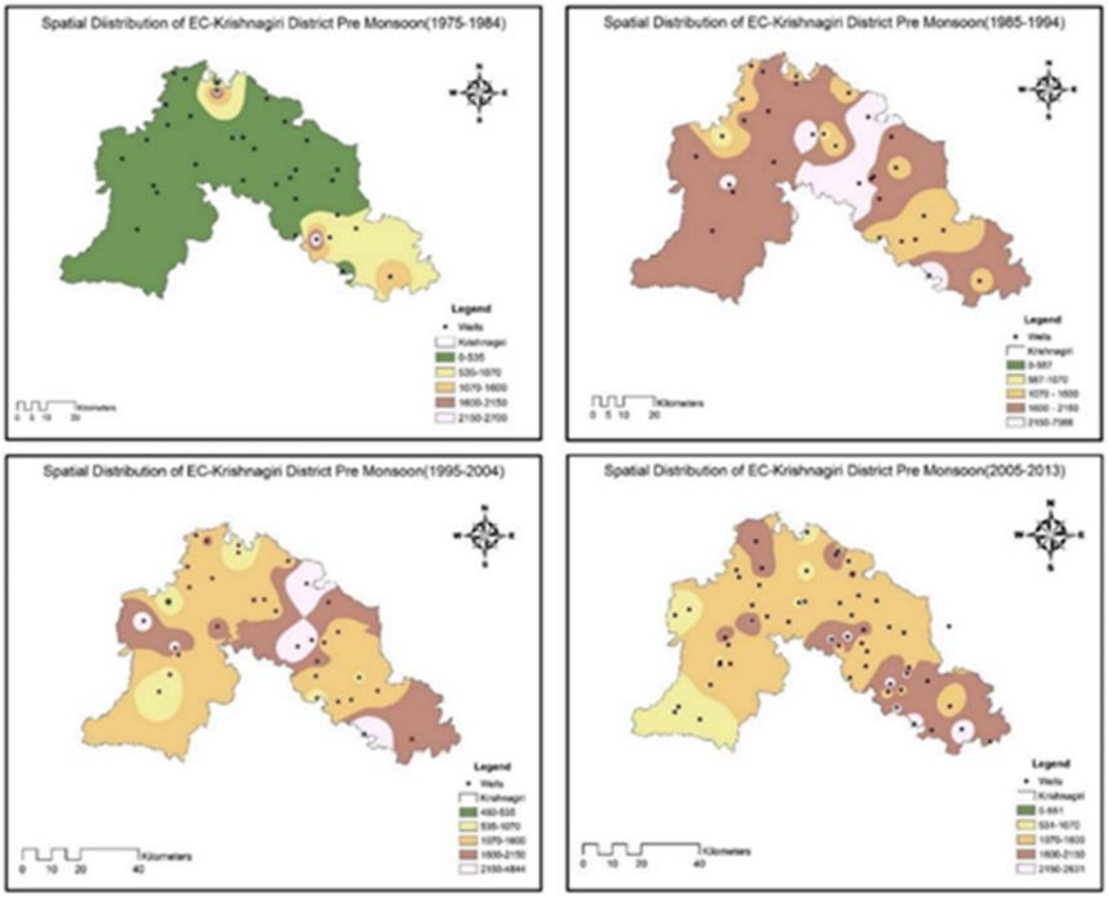

Fig 3: Spatial distribution of Ec over Krishnagiri District (Pre monsoon)

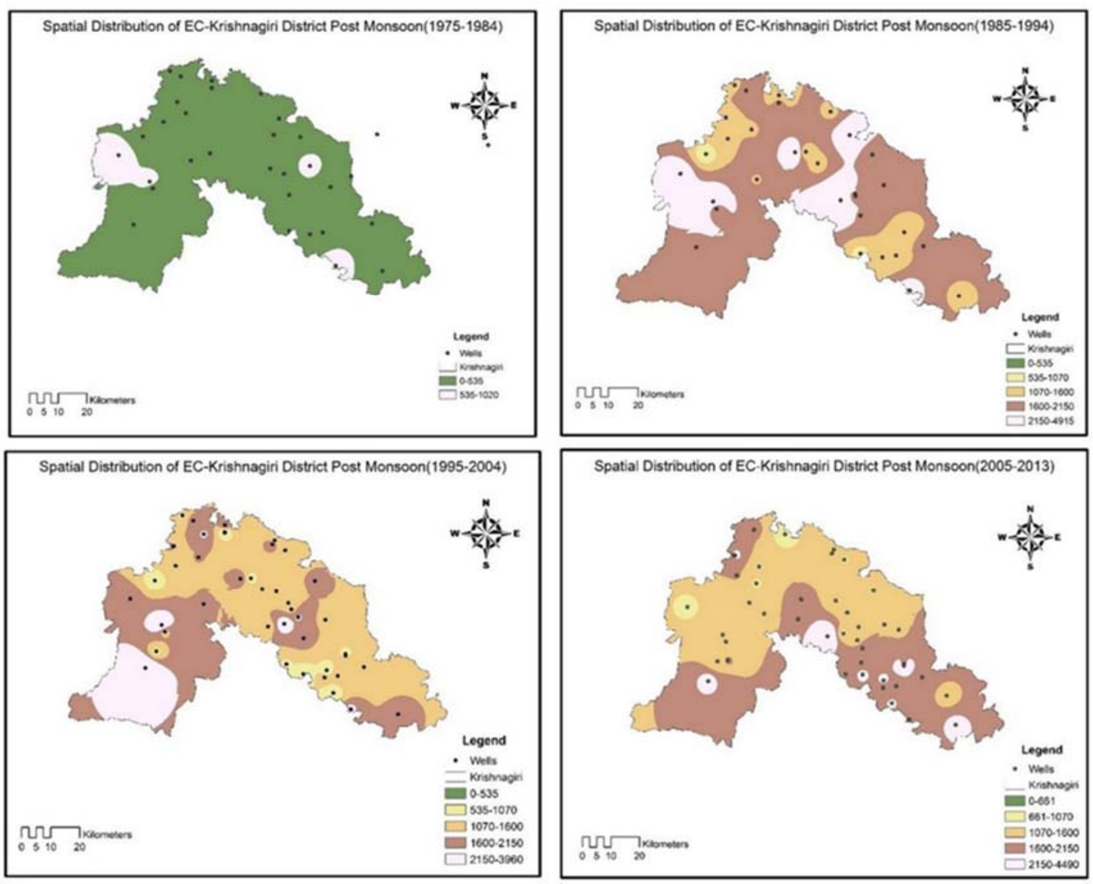

Fig 4: Spatial distribution of Ec over Krishnagiri District (Post monsoon)

Water Quality Index

Water Quality Index, indicating the water quality in terms of a number, offers useful representation of overall quality of water. Hortan (1965) Defined Water Quality Index as a reflection of composite influence of individual quality characteristics on the overall quality of water. For calculation of WQI, selection of parameters has great importance. Since, selection of many numbers of parameters widen the WQI and importance of various parameters depends on the intended use. Eleven Physico-chemical parameters i.e. pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Sulphate (SO_4^{2-}), Nitrate (NO_3^-), Calcium (Ca^{2+}), Chloride (Cl^-), Magnesium (Mg^{2+}), Bicarbonate (HCO_3^-), and Fluoride (F^-) were used to calculate WQI.

Pre-Monsoon Water Quality Index

Water quality index (WQI) of the study area varied from 10.72 to 271.15 during pre-monsoon indicating the water quality during this season ranging from poor to excellent for drinking. Based on these ranges, spatial variability map for WQI value during the pre-monsoon has been obtained. The results show that, out of 82 wells 11 wells were unfit for drinking during 1995-2004, 6 wells were moderately polluted during 1975-84, 18 & 7 wells during 1995-04 & 2005-13, 20 wells were of poor quality during 1975-1984, 3 wells were of poor quality during 1985-94. 8 wells were of poor quality during 199-200 & 31during 2005-2013. Five wells were of good quality during 1975-1984,15 wells were of good quality during 1985-1994,2 wells of were of good quality during1995-04& 16 wells during 2005-2013.4 wells were of excellent quality in 1975-1984.17 & 5 wells were of excellent quality in 1985-94 &2005-13.

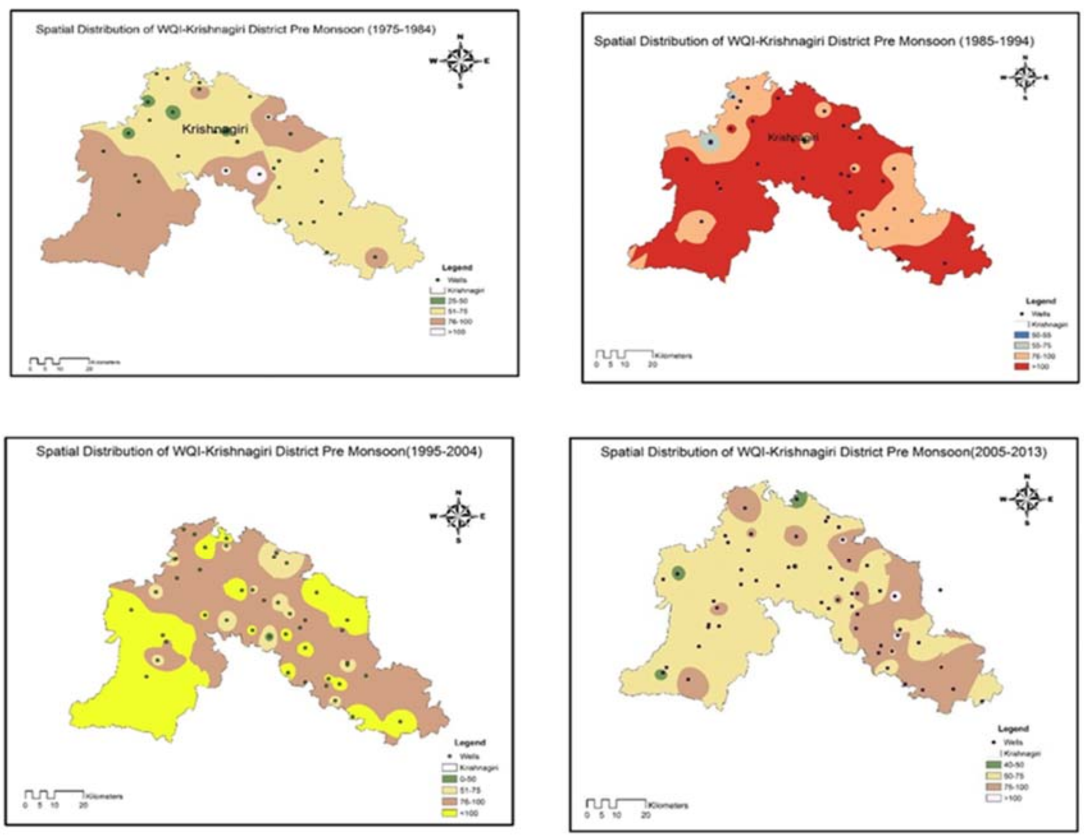

Fig 5: Spatial distribution of WQI over Krishnagiri district (pre monsoon)

For future, the wells may come to poor quality due to high population & industrialization. The value of WQI was due to mixing of sewage, industrial effluent & leaching from waste sight to groundwater. Sewage & industrial effluent contains mixture of different compounds such as magnesium, sulphate & alkalinity & other compounds. All these factors may pose health hazard on long term & can degrade quality of drinking water, therefore required to be treated for drinking purpose. The basin wise spatial distribution of decadal water quality index map for pre monsoon showed that the wells located in the central part of study area of poor quality.

Post-Monsoon Water Quality Index

Water quality index (WQI) of the study area varied from 6.2 to 177.91 during post-monsoon indicating that the water quality during this season ranging from poor to excellent for drinking. Based on these ranges, spatial variability map for WQI during the post-monsoon season has been obtained. The results show that out of 82 wells, 8 wells were of unfit during 2005-13.2 & 17 wells were of moderately polluted quality during 1975-1984, 1995-2004& 2005-13.21 wells were of poor quality during 1975-1984.3wells & 11 wells were of poor quality during 1985-94 & 1995-04 17 wells were of poor quality during 2005-13. 9 & 20 wells were of good quality during 1975-1984 & 1985-94.During 1995-04 & 2005-13, 16 & 4 wells were of good water quality, 3& 12 wells were of excellent quality during 1975-84 & 1985-94.During 1995-04,17wells were of excellent quality. From the basin wise spatial distribution of decadal water quality index map for post monsoon, it was found that the wells located in the south west & south east study area fall under poor quality.

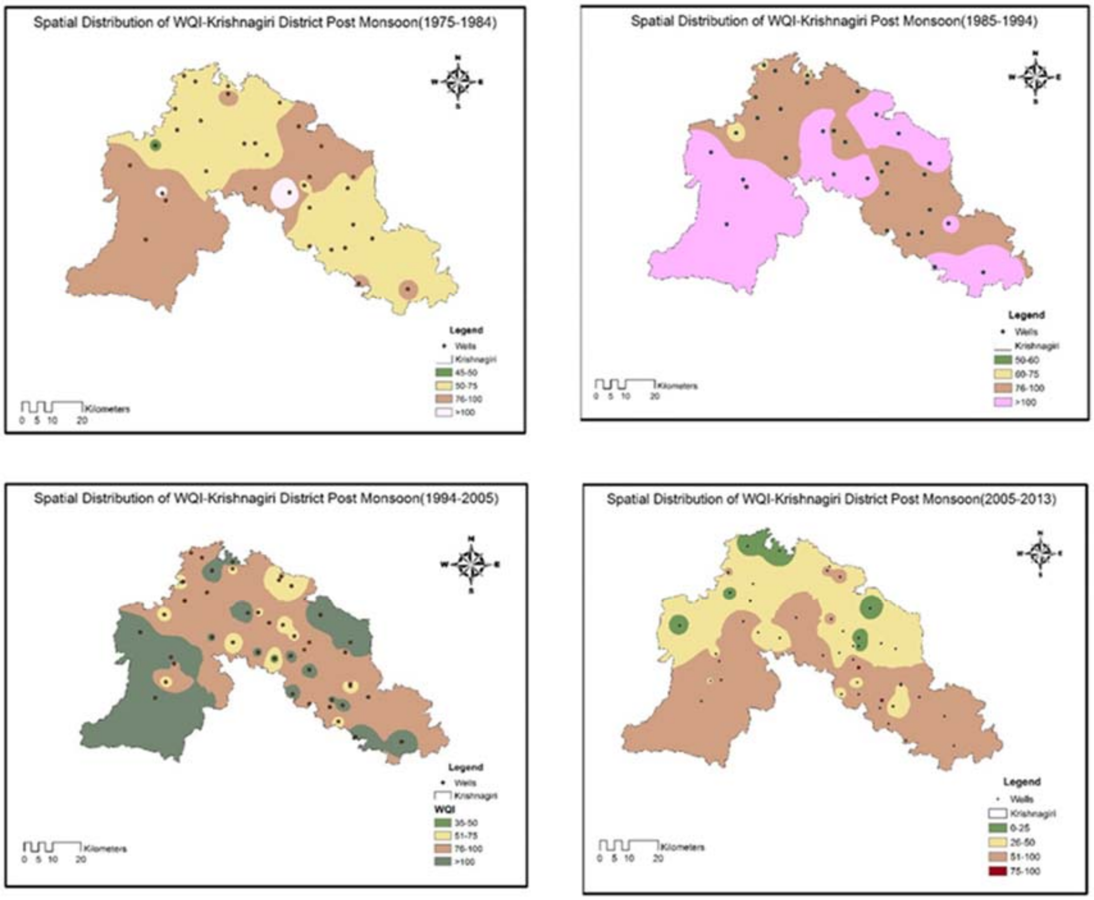

Fig 6: Spatial distribution of WQI over Krishnagiri district (post monsoon)

Table 2: Water Quality Rating With Reference to WQI

WQI Value Range	Water Quality Rating	Pre Monsoon				Post Monsoon			
		1975 -84	1985 -94	1995 -04	2005 -13	1975 - 84	1985 - 94	1995 - 04	2005 -13
0-25	Unfit For Drinking	0	0	11	0	0	0	0	8
26-50	Very Poor (Moderately Polluted)	6	0	18	7	2	0	2	17
51-75	Poor	20	3	8	31	21	3	11	17
76-100	Good	5	15	2	16	9	20	16	4
>100	Excellent	4	17	0	5	3	12	17	0

Table 3: Percentage Change of WQI in Observation Wells over decades.

WQI Value Range	Water Quality Rating	Pre Monsoon				Post Monsoon			
		1975-84	1985-94	1995-04	2005-13	1975-84	1985-94	1995-04	2005-13
0-25	Unfit For Drinking	0%	0%	28%	0%	0%	0%	0%	17%
26-50	Very Poor (Moderately Polluted)	17%	0%	46%	12%	6%	0%	4%	37%
51-75	Poor	57%	9%	21%	53%	60%	9%	24%	37%
76-100	Good	14%	43%	5%	27%	26%	57%	35%	9%
>100	Excellent	11%	49%	0%	8%	9%	34%	37%	0%

Conclusion

The water quality index (WQI) of the study area varied from 10.72 to 271.15 during pre-monsoon indicating the water quality during this season ranging from excellent to poor for drinking. The wells located in the entire study area are fit for drinking purpose. During pre-monsoon, out of 82 observation wells 17 wells are in excellent quality and 15 wells are in good quality 1985-1994. During 1994-2003 the number of excellent wells drastically reduced from 17-0, good quality wells reduced from 15 to 2 and 8 wells are in poor quality. The number of excellent wells increased from 0-5, good quality wells increased from 2 to 16 and also poor quality wells increased from 8 to 31 during 2005-2013. In post monsoon, it was found that the wells located in the South west part of the study area falls under the very poor quality. Water quality index (WQI) of the study area varied from 6.20 to 171.91 during post monsoon indicating the water quality during this season ranging from excellent to very poor for drinking. In post-monsoon season, out of 82 observation wells 12 wells are in excellent quality, 20 wells are in good quality and 3 wells falls under poor quality during 1985-94. During 1995-04 increased from 12 to 17, good quality wells reduced from 20-16 and 11 wells are in poor quality. The number of excellent and good quality wells was reduced, poor quality wells increased from 11-17 and 17 wells falls under the category of very poor quality during 2005-2013.

Annexure- I

WQI of Groundwater during Pre & Post Monsoon Season

	Pre monsoon			Post monsoon		
Well No.	**WQI 1975-84**	**WQI 1985-94**	**WQI 1995-04**	**WQI 1975-84**	**WQI 1985-94**	**WQI 1995-04**
53012	76.86	114.49	50.26	76.23	108.57	102.06
53013	70.33	110.22	79.71	79.11	113.76	119.14
53017	65.04	72.84	22.38	59.36	83.85	59.75
53021	69.11	78.60	20.10	76.65	116.99	125.73
53022	51.64	78.05	13.75	88.32	79.56	80.03
53023	102.60	119.52	78.12	97.28	103.52	106.84
53024	60.05	106.08	30.78	64.67	97.61	101.65
53025	100.07	133.07	36.95	111.08	118.30	142.46
53026	96.06	109.55	39.31	89.72	123.70	120.58
53027	101.71	178.45	33.16	100.32	145.76	66.90
53028	45.74	91.46	29.48	50.98	80.55	91.50
53029	45.04	103.43	26.67	62.72	92.19	82.67
53030	67.58	100.84	25.35	67.58	94.26	95.66
53039	65.87	77.00	38.60	65.79	106.36	177.91
53040	93.21	96.47	14.71	86.75	103.66	92.43
53041	74.63	97.91	28.73	72.36	98.47	75.46
53042	71.69	101.45	38.27	62.33	94.13	67.56
53043	44.96	52.70	10.72	46.12	64.66	131.97
53044	53.16	170.28	20.73	63.17	140.79	91.42
53045	68.54	102.42	55.33	63.73	82.38	56.23
53046	98.18	100.87	11.64	94.83	83.89	115.77
53066	57.31	85.91	19.58	59.87	79.90	94.30
53067	64.86	97.18	45.72	54.95	81.22	85.34
53068	62.22	95.69	15.01	66.58	75.78	95.67
53070	67.89	103.09	25.15	65.99	85.47	107.36
53071	63.32	151.49	46.35	55.09	92.23	117.28
53072	129.90	271.15	45.10	153.40	125.18	148.71
53073	97.77	125.63	32.54	87.21	109.28	80.39
53074	59.31	88.11	60.58	63.30	88.04	94.31
53075	49.34	75.48	71.90	60.44	84.76	91.09
53076	50.62	64.77	17.95	56.36	71.01	87.49
53077	45.75	96.65	65.76	51.01	80.41	136.79
53078	49.07	80.15	15.85	47.78	72.33	77.22
53079	57.68	85.39	35.97	55.62	79.02	68.91
53017A	73.20	89.05	51.44	66.39	78.08	88.91

WQI of Groundwater during Pre & Post Monsoon Season

Well No.	**Pre monsoon**	**Post monsoon**	**Well No.**	**Pre monsoon**	**Post monsoon**	**Well No.**	**Pre monsoon**	**Post monsoon**
	WQI 2005-13	**WQI 2005-13**		**WQI 2005-13**	**WQI 2005-13**		**WQI 2005-13**	**WQI 2005-13**
17083	95.10	59.43	17103	55.15	36.64	53072	81.83	71.01
17084	73.87	74.78	17105	96.77	14.23	53074	58.47	18.39
17085	77.01	60.45	17106	105.92	49.75	53017A	74.70	37.13
17086	75.78	49.78	53012	95.97	55.70	53018A	78.17	68.46
17087	64.17	66.49	53013	88.23	6.20	53027A	100.89	69.58
17088	51.81	48.52	53017	52.58	17.29	HP17014	49.69	45.32
17089	37.40	8.31	53018	55.95	79.63	HP17016	61.38	65.49
17090	89.51	46.08	53020	43.06	42.68	HP17017	66.55	75.47
17091	40.18	46.99	53024	64.06	26.43	HP17018	76.65	-
17092	88.31	31.89	53025	55.47	68.84	HP17019	49.71	-
17093	55.85	15.92	53029	77.14	47.13	HP17020	56.91	-
17094	68.79	50.45	53039	53.65	48.31	HP17021	62.87	-
17095	58.65	61.27	53041	96.34	57.15	HP17022	54.94	-
17096	104.50	37.09	53042	59.97	77.63	HP17023	54.94	-
17097	83.93	14.80	53045	68.23	44.62	HP17024	51.86	-
17098	123.02	22.38	53066	73.63	50.97	HP17028	44.88	-
17099	67.32	66.56	53067	85.46	52.60	HP17031	66.08	-
17100	66.22	39.59	53070	109.65	47.08	HP17032	45.76	-
17102	74.83	77.60	53071	86.81	52.39	HP17038	54.31	-

References

1. Aguilera H, Murillo JM. The effect of possible climate change on natural groundwater recharge based on a simple model: A study of four karstic aquifers in SE Spain. Environmental Geology. 2009; 57(5):963-974.
2. Ahamed A, Jafar, Loganathan K. Assessment and correlation analysis of surface and groundwater of Amaravathy river basin-Karur, Tamil Nadu, India. J of Chemical and Pharmaceutical Res. 2012; 4(8):3972-3983.
3. Amaresh KR, Singh, Raviprakash S. An integrated approach of remote sensing, geophysics and GIS to evaluation of groundwater potentiality of Ojhala sub-watershed, Mirzapur district, U.P., India. Map India Water Resources, 2003.
4. Balakrishnan P, Abdul Saleem, Malllikarajun ND. Groundwater quality mapping using geographical information system (GIS): A case study of Gulbarga City, Karnataka, India. African Journal of Environmental Science and Technology. 2011; 5(12):1069-1084.
5. Central Ground Water Board (CGWB). Groundwater Year Book – India, 2010-11.
6. Chatterjee C, Raziuddin M. Determination of water quality index (WQI) of a degraded in Asanol industrial area, Raniganj, Burdwan, West Bengal. Nature, Environment and Pollution Technology. 2002; 1(2):181-189.
7. Kartikeyan N, Saranya A, Sashikumar MC. Spatial analysis of groundwater quality of Virudhunagar district, Tamil Nadu using GIS. International J of Remote Sensing and Geoscience. 2013; 2(4):23-30.
8. Kumar CP. Climate Change and its impact on Groundwater Resources. International Journal of Engineering and Sci. 2012; 1(5):43-60.
9. Ward CF. Impact of human activity on groundwater quality in rural areas. Chapman and Hall, London, 1994, 109-111.
10. World Health Organization (WHO). Guidelines for drinking water quality, 3rdedn. World Health Organization, Geneva, 2004.