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## Characterization of Groundwater with Special Emphasis on Seasonal Variation in Jagalur taluk, Davangere District of Karnataka, India

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**ABSTRACT:** The appraisal of ground water is the chief mandatory in developing country especially in rural based economy country in India, It required to develop a strategy for sustainable developmental activities through investigation of hydrological cycle. In the current study, appraisal of ground water with special emphasis on seasonal variation in ground water and changes in the quality have been conducted for Jagalurtaluk located in central part of Karnataka state, India. Ground water quality results were collected during two period (pre-monsoon and post monsoon) in the year 2020-2021. Ground water quality results were used to calculate the GWQI and IWQI for its suitability for drinking and agricultural needs respectively. Total seven (pH, TDS, TH, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>-</sup>, Na<sup>+</sup>and K<sup>+</sup>) various physico-chemical variables were chosen for analysis. Results of the current work predicts based on TDS showed satisfactory and safe for drinking and other variables indicates, out of collected water samples about 50% of samples are poor group, 50% are very poor group for drinking as per GWQI. For appraisal of water quality for irrigation USSL, SAR and RSC are calculated. Evaluated values of IWQI shows the ground water samples are not suitable for irrigation in post-monsoon compared to pre monsoon period.

**KEYWORDS:** Seasonal, USSL, GWQI, IWQI, SAR and RSC

#### I. INTRODUCTION

The appraisal of groundwater quality is a significant as its diverse needs ranging from drinking to agriculture followed by industrial activity in al over world (Subramani and Damodarasamy 2005). The physico-chemical and biological properties of the ground water indicates the quality. The various sources of the variables are functions especially ecological functions and encourages the geological activity also manmade activities (Ganiy, et al., 2018). Pollution by solid waste dumping is the main threat to formation of leachate and encourages the anaerobic decomposition which may leads into the aquifer (Tesfaye, 2007). Contamination of aquifer is the chief problem due to rapid growth in population, industrial activity and conversion of rural into urban especially in Mahanagarpalike in India. Due to usage of ground water, the quality will changes seasonally and monthly since changes in the physico-chemical properties (Ramakrishnaiah, et al. 2009).

Excessive extraction, decrease in recharging process, modern agricultural practices have extends the condition of the ground water and shrinking groundwater, colour of the water changes into brackish at some places where leachate contamination (Venu and Rishi, 2010).Hence, usage of contaminated water in irrigational needs may affects the crop production and also may leads changes in the process of aquifer means degradation in the quality. Since the geological structure gives the ground water and land are is closely attracts the crop production. Hence, in the present work undertaken to apprise the ground water quality with special emphasis to seasonal variation using Ground water quality index (GWQI) and Irrigation Water Quality Index (IWQI) for utilization for drinking and agricultural needs respectively.



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#### **II. MATERIALS AND METHODS**

#### Study a rea

Jagalurtaluk located in the central parat of Karnataka, is one of the agricultural area which lies from Latitude  $14.50^{\circ}N - 14.52^{\circ}N$ , longitude  $76.33^{\circ}E - 76.35^{\circ}E$ , Geographical location of the taluk is 978 sq. km. Jagalutaluk is one of the panchayath town in the Davangere district. Normal rainfall of the taluk is 546 mm. Seasonal rainfall outline indicates that, chief amount of (289 mm) rainfall was recorded during South-West Monsoon periods, which contributes about 52% of the yearly normal precipitation. Agriculture is the main source of the taluk and about 11% of population of the Davangere district are living in Jagalurtaluk. The soil of the taluk are classified into three are red, sandy and cotton block. The soil are predominantly occupies 24%, 33% and 43% of the area respectively. The main agricultural crops are Ragi, Jowar, oil seeds, chilly, pulses and cotton. The 60% of the taluk is dependent on ground water for agricultural and 35% for drinking including domestic needs. Total agricultural land is about 13,264 hectare.

#### Methods of Analysis

The methodology adopted, noticed monthly rainfall data and periodically collected the groundwater levels. Samples are collected from different 16 bore well which are used for irrigational and drinking needs (BIS, 10500: 1991) and WHO (1996) standards). The monthly samples area collected and classified into pre-monsoon and post-monsoon period during the year 2020 - 2021. The rainfall data were recorded during the study period is as shown in Figure. The Figure 2 and Figure 3 indicates the ground water level during post and pre monsoon period. The rain fall data during study period(Figure 1). Total seven different water quality variables like pH, TDS, TH, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>-</sup>, Na<sup>+</sup>, and K<sup>+</sup> were selected to appraise Ground water quality for 16 bore well samples sictuated in Ninganahalli, Madammanahalli, Chadaragolla, Sagalagatta, Santhemuddapura, Lambanihatti, Kartigere, Herearakere, Muggidaranahalli, Narenahalli, Ajjabommonahalli, Settigondanahalli, Borapura, Kallenahalli, Matigettahalli and Vaddarahatti villages of Jagalurtaluk, central part of Karnataka, India. Variables are weighted as per their observedsignificance to overall GWQI is calculated as the weighted mean of all analysed results (Bharti and Katyal 2011). Table 2, 3, 5 and 6 defines the determined values using GWQIformula (Bharti and Katyal, 2011 and Sharma and Chhipa, 2012).



Figure 1. Average monthly variation in rainfall distribution of JagalurTaluk

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#### Quality conditions for drinking water (GWQI)

Quality guidelines for drinking water quality pH, TDS, Total hardness (TH),  $Ca^{2+}$ ,  $Mg^{2+}Cl^{-}$  and  $SO_4^{-}$ , for irrigational the variables are pH, TH,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Cl^{-}$ ,  $Na^{+}$ ,  $SO_4^{2-}$  and  $K^{+}$  the variables are chosen for water quality analysis respectively are given in Table 1. The pH of selected ground water during the study period ranges between 7.60 and 840 in post monsoon and 7.40 and 8.40 in pre-monsoon periods. In the entire study period maximum pH was 8.4 is encountered. According to the drinking water guidelines given by ISI, WHO, ICMR during the study period all most all 16 samples are shown satisfactory and safe for drinking (Kamble and Saxena 2016; Chavan and Zambare 2014 and Suresh B. 2015).TDS is the simplest categorization of water is depend upon the total content of dissolved solids (Davis and Dewiest, 1966). TDS during the study period ranges between from 523 mg/l and 1546 mg/L in post-monsoon and 505 mg/L and 1892 mg/L in post monsoon. The difference in TDS content during the periods are shown in Table 1 and 4.

Total hardness (TH) during the study period ranges between 221 mg/L in pre- monsoon and 960 mg/L in pre-monsoon season. In pre monsoon 65% of the ground water samples are very hard, 35% are hardy category. In post monsoon 30% of samples are hard water and 48% are very hard category. TH values of all most all samples in the study area are exceeds the maximum allowable limits (ISI and WHO guidelines). The variation in TH concentration with season is shown in the following Table 5. Maximum allowable limit for TH is 300 mg/L. Calcium (Ca<sup>2+</sup>): In all most all the lotic and lentic waters Ca<sup>2+</sup> is the most common element. It is significant cation it values ranges between during the study period is 124 mg/L in post-monsoon and 275 mg/l in post-monsoon periods (Figure 4). Low content of < 25 mg/l is recorded in some of the areas which are nearer to irrigated land. Maximum allowable limit (Figure 4). Magnesium (Mg<sup>2+</sup>): In the current study, Mg<sup>2+</sup> content is less than Ca<sup>2+</sup> it varies from 40- 165 mg/l. All most all the samples indicates more than 30 mg/l. Maximum content of above 165 mg/l is recorded in cotton soil and in some low lying zones. Mg<sup>2+</sup> values for the all most all the samples are above the allowable limits (ISI and WHO Standards). Maximum content of Mg<sup>2+</sup>may cause laxative effect an especially on daily users (Figure 5). Mg<sup>2+</sup> deficiency is related with functional and structural aspects of human body. It is required as an indicator of many enzyme activities (Figure 5).

During the study period, in both pre and post monsoon season about 50% of the ground water samples are shown poor condition and 50% of the samples are very poor group based on the GWQI is given in Table 7.



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#### Quality conditions for irrigation water (IWQI)

A total of 16 underground water samples taken in different villages in Jagalurtaluk were collected in monthly and calculated for two season. The collected samples during pre-monsoon (February, March and April, 2020) and post monsoon (November, December 2019 and January – 2020) in covered cap and high density PVC cans with 5 litre capacity and 1mL toluene was added to control the biological action. The samples analysed for different variables like, pH, EC, cationare ( $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Na^+$ ) and anionis ( $Cl^-$ ,  $SO_4^{2-}$ ) as per guidelines reported by Richards (1954).  $Ca^{2+}$  and  $Mg^{2+}$  were analysed by titrometric, while Na<sup>+</sup> and K<sup>+</sup> were estimated using flame photometer. The  $Cl^-$  and  $SO_4^{2-}$  were analysed by titration with titrometric and UV spectrophotometer respectively. The obtained results were used to calculate sodium adsorption ratio (SAR) and residual sodium carbonate (RSC). Based on SAR and RSC, underground water quality based on the criteria for irrigation was grouped used by Minhas et al. (1998b) is given as follows Good (SAR < 10 meq/L, RSC < 2.50 meq/L), alkali (SAR > 10 meq/L, RSC > 4.0 meq/L).

The SAR and RSC are used as irrigational index of the sodium hazard used by Ramprakash et al., 2013. Using SAR and RSC values are given in Table 7, however the average of calculated SAR values in all most all the samples are showed <10 which are indicates alkalinity and effects of sodacity was identified but not problematic the same trends were observed by Minhas et al., 1998b). Maximum SAR was recorded in Kartigere (JWS<sub>7</sub>) is 7.22 during post monsoon season. Earlier work done by Ramprakash et al., (2013) also notices 32.0% of water samples were of good quality and 56.0% saline and 12.0% alkali in nature in Beri block of Jhajjar district in Haryana. Similarly, in the present study reported 20.8 % and 30.6% of groundwater with different kinds of salinity problems during post and pre monsoon season respectively.

As per to Eaton, (1950) equitation, as water alkalinity enhances by the soil and also indirectly reduces the growth of plant. The RSC of water exceeding 2.5 meq/l, is unsuitable for yield of crop indirectly soil quality (Allison, et al., (1954). RSC values > 4.0 meq/l are recorded as alkali nature, < 2.5meq/l are said to begood group. Negative values of RSC are to be considered as suitable for irrigation group. In the present study, all most all the samples possessed negative results, which indicates the earth properties comes under alkaline condition. The same trends were observed by (Gorthi, et al., 2015).

#### **III. CONCLUSIONS**

Maximum content of TDS during post monsoon samples predicts poor quality of water as compared to Pre monsoon this is may be due to interpretation of sewage, agricultural runoff and leachate filtering into the ground during post monsoon. During the study period in both seasons show same trends of sodium content as prescribed by WHO. Study predicts, Jagalurtalukof central part of Karnataka showed maximum of sodium content. In most of the area, chloride and sulphate content increases, study of GWQI revealed that the drinking water about 50% of the locations are in poor category and 50% showed very poor category and found to be more polluted.

The dominant cation and anion in the ground water of Jagalurtaluk are  $Na^+$  and  $Cl^-$ , sodium chloride, hence the distribution of salts in the aquifer. Ground water in the study area is alkaline in pre- and post-monsoon period's non-carbonate alkali controlled by evaporation (Figure 6). TDS values in all most all the ground water samples showed



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more during post monsoon periods are exceeding drinking water standards of WHO. TDS levels in all groundwater samples in both seasons are above drinking water standards.

#### **Conflict of Interest**

The authors declare that there are no conflicts of interest concerning the publication of this manuscript.

	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13	MW-14	MW-15	MW-16
pH	7.70	7.90	7.60	8.00	7.60	8.10	8.40	7.60	7.70	8.00	8.10	7.50	7.90	7.80	7.40	7.90
TDS	963.00	856.00	725.00	575.00	1105.00	505.00	582.00	987.00	754.00	943.00	956.00	923.00	978.00	961.00	1892.00	675.00
Cl	158.00	160.00	155.00	174.00	306.00	168.00	172.00	314.00	196.00	192.00	183.00	461.00	452.00	270.00	415.00	375.00
TH	372.00	744.00	671.00	252.00	533.00	252.00	275.00	936.00	221.00	823.00	832.00	943.00	915.00	818.00	960.00	488.00
Ca2+	275.00	144.00	145.00	130.00	188.00	126.00	128.00	238.00	188.00	132.00	138.00	240.00	235.00	185.00	266.00	245.00
Mg <sup>2+</sup>	90.00	95.00	80.00	66.00	95.00	48.00	50.00	46.00	43.00	95.00	90.00	56.00	84.00	49.00	145.00	60.00
\$0,:	22.00	27.00	23.00	22.00	79.00	22.00	28.00	125.00	27.00	24.00	27.00	140.00	127.00	47.00	98.00	47.00
Na <sup>+</sup>	171.00	138.00	190.00	211.00	83.00	198.00	267.00	275.00	260.00	273.00	184.00	205.00	225.00	206.00	270.00	98.00
K	3.80	2.00	4.00	5.10	3.00	3.70	4.00	3.30	3.70	2.80	3.60	3.00	7.30	6.80	7.00	5.50

#### Table 1. Post-monsoon Observed values for GWQI variables

#### Table 2. Post-monsoon Wi/Qi values for GWQI variables

	Wi/Qi	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13	MW-14	MW-15	MW-16
pН	0.125	110.00	112.86	108.57	114.29	108.57	115.71	120.00	108.57	110.00	114.29	115.71	107.14	112.86	111.43	105.71	112.86
TDS	0.10	68.79	61.14	51.79	41.07	78.93	36.07	41.57	70.50	53.86	67.36	68.29	65.93	69.86	68.64	135.14	48.21
Cľ	0.05	63.20	64.00	62.00	69.60	122.40	67.20	68.80	125.60	78.40	76.80	73.20	184.40	180.80	108.00	166.00	150.00
TH	0.075	74.40	148.80	134.20	50.40	106.60	50.40	55.00	187.20	44.20	164.60	166.40	188.60	183.00	163.60	192.00	97.60
Ca <sup>2+</sup>	0.075	137.50	72.00	72.50	65.00	94.00	63.00	64.00	119.00	94.00	66.00	69.00	120.00	117.50	92.50	133.00	122.50
Mg <sup>2+</sup>	0.075	60.00	63.33	53.33	44.00	63.33	32.00	33.33	30.67	28.67	63.33	60.00	37.33	56.00	32.67	96.67	40.00
\$0;	0.1	5.50	6.75	5.75	5.50	19.75	5.50	7.00	31.25	6.75	6.00	6.75	35.00	31.75	11.75	24.50	11.75
Na†	0.05	1710.00	1380.00	1900.00	2110.00	830.00	1980.00	2670.00	2750.00	2600.00	2730.00	1840.00	2050.00	2250.00	2060.00	2700.00	980.00
K	0.05	7.60	4.00	8.00	10.20	6.00	7.40	8.00	6.60	7.40	5.60	7.20	6.00	14.60	13.60	14.00	11.00

Table 4. Pre-monsoon Observed values for GWQI variables

	MW-															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
pН	7.8	8.0	8.2	8.3	7.9	8.1	8.4	7.6	8.2	8.0	7.8	8.1	7.8	8.2	8.0	7.8
TDS	511.0	483.0	594.0	426.0	499.0	583.0	641.0	487.0	516.0	493.0	518.0	604.0	651.0	666.0	504.0	547.0
Cľ	166.0	324.0	235.0	196.0	225.0	191.0	122.0	361.0	284.0	272.0	234.0	465.0	331.0	363.0	405.0	392.0
TH	630.0	716.0	951.0	483.0	410.0	505.0	523.0	894.0	765.0	688.0	862.0	941.0	794.0	844.0	512.0	781.0
Ca <sup>2+</sup>	246.0	234.0	245.0	124.0	131.0	143.0	135.0	146.0	138.0	264.0	187.0	153.0	146.0	237.0	186.0	192.0
Mg <sup>2+</sup>	79.0	81.0	72.0	45.0	42.0	46.0	40.0	125.0	85.0	81.0	115.0	110.0	115.0	165.0	120.0	90.0
SO <sub>4</sub>	48.0	81.0	75.0	89.0	42.0	39.0	44.0	58.0	39.0	45.0	33.0	68.0	42.0	60.0	72.0	80.0
Na <sup>+</sup>	182.0	153.0	191.0	240.0	182.0	205.0	267.0	275.0	253.0	271.0	188.0	205.0	231.0	244.0	312.0	188.0
K <sup>+</sup>	4.5	4.2	6.2	5.4	5.2	4.5	5.3	4.1	5.3	4.8	3.4	3.8	8.4	7.3	7.1	5.7



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#### Table 5. Pre-monsoon Wi/Qi values for GWQI variables

	Wi/Qi	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13	MW-14	MW-15	MW-16
pН	0.125	111.43	114.29	117.14	118.57	112.86	115.71	120.00	108.57	117.14	114.29	111.43	115.71	111.43	117.14	114.29	111.43
TDS	0.05	66.40	129.60	94.00	78.40	90.00	76.40	48.80	144.40	113.60	108.80	93.60	186.00	132.40	145.20	162.00	156.80
Cl	0.075	126.00	143.20	190.20	96.60	82.00	101.00	104.60	178.80	153.00	137.60	172.40	188.20	158.80	168.80	102.40	156.20
TH	0.075	123.00	117.00	122.50	62.00	65.50	71.50	67.50	73.00	69.00	132.00	93.50	76.50	73.00	118.50	93.00	96.00
Ca <sup>2+</sup>	0.075	52.67	54.00	48.00	30.00	28.00	30.67	26.67	83.33	56.67	54.00	76.67	73.33	76.67	110.00	80.00	60.00
Mg <sup>2+</sup>	0.1	12.00	20.25	18.75	22.25	10.50	9.75	11.00	14.50	9.75	11.25	8.25	17.00	10.50	15.00	18.00	20.00
\$0;	0.05	1820.00	1530.00	1910.00	2400.00	1820.00	2050.00	2670.00	2750.00	2530.00	2710.00	1880.00	2050.00	2310.00	2440.00	3120.00	1880.00
Na <sup>+</sup>	0.05	9.00	8.40	12.40	10.80	10.40	9.00	10.60	8.20	10.60	9.60	6.80	7.60	16.80	14.60	14.20	11.40
K	0.125	111.43	114.29	117.14	118.57	112.86	115.71	120.00	108.57	117.14	114.29	111.43	115.71	111.43	117.14	114.29	111.43

#### Table 6. Pre-monsoon Si values for GWQI variables

	Si	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13	MW-14	MW-15	MW-16
pH	0.125	13.93	14.29	14.64	14.82	14.11	14.46	15.00	13.57	14.64	14.29	13.93	14.46	13.93	14.64	14.29	13.93
TDS	0.050	3.32	6.48	4.70	3.92	4.50	3.82	2.44	7.22	5.68	5.44	4.68	9.30	6.62	7.26	8.10	7.84
Cľ	0.075	9.45	10.74	14.27	7.25	6.15	7.58	7.85	13.41	11.48	10.32	12.93	14.12	11.91	12.66	7.68	11.72
TH	0.075	9.23	8.78	9.19	4.65	4.91	5.36	5.06	5.48	5.18	9.90	7.01	5.74	5.48	8.89	6.98	7.20
Ca <sup>2+</sup>	0.075	3.95	4.05	3.60	2.25	2.10	2.30	2.00	6.25	4.25	4.05	5.75	5.50	5.75	8.25	6.00	4.50
Mg <sup>2+</sup>	0.100	1.20	2.03	1.88	2.23	1.05	0.98	1.10	1.45	0.98	1.13	0.83	1.70	1.05	1.50	1.80	2.00
80 <sub>4</sub> -	0.050	91.00	76.50	95.50	120.00	91.00	102.50	133.50	137.50	126.50	135.50	94.00	102.50	115.50	122.00	156.00	94.00
Na†	0.050	0.45	0.42	0.62	0.54	0.52	0.45	0.53	0.41	0.53	0.48	0.34	0.38	0.84	0.73	0.71	0.57
K,	0.125	13.93	14.29	14.64	14.82	14.11	14.46	15.00	13.57	14.64	14.29	13.93	14.46	13.93	14.64	14.29	13.93

#### Table 7. GWQI, SAR and RSCfor Samples

		GW	/QI	SAR,	meq/L	RSC,	meq/L
Code	Name of the village	Post	Pre	Post	Pre	Post	Pre
JWS <sub>1</sub>	Ninganahalli	170	158	3.426	3.044	-13.399	-17.874
JWS <sub>2</sub>	Madammanahalli	167	152	3.088	3.444	-9.728	-5.758
JWS <sub>3</sub>	Chadaragolla	189	172	4.131	4.580	-5.487	-2.397
JWS <sub>4</sub>	Sagalagatta	194	172	5.919	5.138	-4.999	-7.880
JWS <sub>5</sub>	Santhemuddapura	189	126	1.898	1.266	-23.217	-24.744
JWS <sub>6</sub>	Lambanihatti	183	169	5.371	4.971	-2.286	-3.558
JWS <sub>7</sub>	Kartigere	218	205	7.226	6.717	-1.693	-3.617
JWS <sub>8</sub>	Herearakere	224	221	5.847	5.891	-11.385	-10.086
JWS <sub>9</sub>	Muggidaranahalli	209	207	6.074	6.090	-8.088	-7.070
JWS <sub>10</sub>	Narenahalli	222	215	5.698	6.612	-11.396	-6.280
JWS <sub>11</sub>	Ajjabommonahalli	179	173	3.962	4.994	-9.888	-2.722
JWS <sub>12</sub>	Settigondanahalli	201	200	4.357	3.566	-7.944	-5.402
JWS <sub>13</sub>	Borapura	212	219	4.697	4.365	-6.390	-8.017
JWS <sub>14</sub>	Kallenahalli	230	198	4.434	4.673	-7.266	-4.602
JWS <sub>15</sub>	Matigettahalli	247	235	5.353	5.635	-16.089	-12.622
JWS <sub>16</sub>	Vaddarahatti	185	134	3.000	2.011	-9.345	-8.134

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Figure 6. USSL classification during post and pre - monsoon season

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