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Determination of Physio-Chemical Parameters and Water Quality Index (Wqi) of Kundapura Taluk, Udupi District, Karnataka, India

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Abstract: The determination of various physio-chemical parameters and water quality index of Kundapura Taluk uses nine parameters: pH, electrical conductivity, total dissolved solids, total hardness, alkalinity, acidity, chlorides, dissolved oxygen and chemical oxygen demand, measured in 40 places. The weighted arithmetic water quality index (WAWQI) method is used for the calculation of water quality index. The present study area is Kundapura Taluk in Udupi district, Karnataka located between a 74°34′40.0′′ E to 75°4′57.35′′ E longitude, and a 13°59′33.26′′ N to 13°28′40.82′′ N latitude. According to post-summer values of pH, places such as MITK, Margoli and Kodi have high pH, and Kumbashi and Amavasyebailu have low pH. Places such as Margoli, Beejadi, Senapura, Kollur and Kodi show higher E.C, and Amparu shows a lower value of E.C. Alkaline water balances the pH of the body, and we found higher alkalinity in Kodi, Beejadi, Marvanthe and lower alkalinity in Yedthare, Mullikatte and Trasi. All water samples with higher COD content were found post-summer which diminishes the amount of D.O content in water. Pre-summer and post-summer values shows numerous changes in values. In the post-summer, water level decreases mechanically due to increases in water extraction: it causes a cone of depression at ground water level, creating a saltwater intrusion in which water loses its quality, thus pre-treatment is additional, post-summer.

Keywords: ground water; water parameters; water quality; Kundapura; physio-chemical analysis

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1. Introduction

Quality of water is a function of the physical, chemical and biological parameters, and is influenced by natural and anthropogenic effects, including local climate, geology and irrigation practices. The chemical character of any ground water determines its quality and utilization. Globally, the major demand for fresh water is preferably fulfilled through the extraction of surface water from water bodies, such as lakes, rivers, and ponds [1–14]. Water used for irrigation can vary greatly in quality depending upon the type and quantity of dissolved salts in their respective region. On these bases, the various technical research papers on the assessment of ground water quality for lakes, beaches, industrial areas, near rivers, residential colonies and different areas have been presented at a research level [4–11]. All the parameters for drinking water analyzed were found to be within the permissible limit except for the chloride content in Suvarna river water samples. However, it was suggested to monitor the surface and ground water quality regularly to ensure sustainable usage. Ground water sampling and monitoring are also required on an ongoing basis to back up hydrogeological studies and to more accurately assess water quality and propose sustainable management strategies [2,8,10,12,13]. The ground water is classified as soft water based on hardness in the Varahi river basin. Ground water has a low alkali (sodium ion) hazard, and a low to moderate salinity hazard for drinking and irrigation purposes. Few samples with higher water salinity require regular leaching/better drainage in soils and special management for salinity control, otherwise it presents an appreciable sodium hazard in fine textured soils. In the latter case, it should be used only in coarse-textured soils for salt-tolerant plants [3,6,8,9]. According to Vijay Kumar et al., the evaluation of the water quality of the mangroves ecosystem in Kundapura region, reveals that, as the seasons change, there is a fluctuation in the physio-chemical characters of the water: this will be due to constant fluctuation, and a change in the temperature and salinity as the season changes. The present water quality of the Kundapura mangrove ecosystem reveals that salinity plays a dominant role in controlling the water quality. In addition, intense pollution from both agricultural inputs and shrimp culture ponds deteriorates the water quality of the mangrove ecosystem. As per the Government of India, Ministry of Water Resources Central Ground Water Board (Status of Ground Water Quality in Coastal Aquifers of India) survey in February 2014, along the 225 km long coastline of Karnataka, in the three districts of Uttara Kannada, Dakshina Kannada and Udupi, there occurs a narrow strip of coastal alluvium underlain by Precambrian crystalline. Its width varies from a few meters to 4 km at places. Tertiary laterite capping on schists and granites are seen at places [15]. Coastal alluvium comprises fine to medium grained sand, clay and gravels. The thickness of alluvium is around 35 to 45 m near the coast and gradually decreases landward up to 10 m. The yield of the dug wells range from 1.8 to 297 m^3/day in sand. Laterites form productive aquifers in areas close to valley portions. The yield of wells in laterites ranges from less than 2 to 280 m^3/day. Considering the research gap, the prioritization of ground water based on their biological richness, vulnerability and conservation strategies is performed in this study. In this regard, conservation methods include rainwater harvesting, trenches for conserving water, which increases the infiltration rate, and suggested alternative fresh water wells for the study area.

2. Study Area

Kundapura Taluk is located in Udupi district of Karnataka. Kundapura is the northern taluk of Udupi district and has a geographical area of 1569 sq. km. It lies between a 74°34′40.0′′ E to 75°4′57.35′′ E longitude and a 13°28′40.82′′ N to 13°59′33.26′′ N latitude (Figure 1). This taluk has many rivers and experiences significant precipitation. The main streams are the Venkatapura river, Kollur river (tributaries of Chakra and Souparnika), Haladi-Varahi river, Sita river, Yadamavina Hole and Uppunda hole. Kundapura is encircled by Udupi Taluk towards South, Bhatkal Taluk towards North, Hosanagara Taluk towards East, Karkal Taluk towards South and Arabian sea in the west. Kundapura is encircled by Udupi Taluk towards the south, Bhatkal Taluk towards the north, Hosanagara Taluk towards the east and Karkal taluk towards the west [10]. The soil is of a lateritic type characterized by a high iron and aluminum content. Because of seasonal differences in rainfall, the ground water level varies from season to season. The water levels are deepest before the start of the southwest monsoon, in May, and shallowest in August/November. The region is occupied by geological rocks, such as granitic gneisses, with occasional laterite capping and unconsolidated river and marine sediments. The taluk is primarily dependent on the southwest monsoon, which provides approximately 86–88 percent of the rainfall. Padukone, Uppinakudru, Trasi, Mravanthe, Byndoor, Kodi and Gangolli are some villages near to coast. Kollur (Kodachadri), Kundadri, Mudoor are the major hilly areas in Kundapura Taluk. Kundapur, supplying enough drinking water to people living in 101 villages, is covered by 56 grama panchayats of the taluk and has become a mammoth ordeal for the local bodies. One or more areas in each of these villages are left thirsty because of water scarcity and official apathy. The problem of sea water getting mixed with the underground water table has become acute in many of the gram panchayats, such as Gangolli and Tallur, which are located on the seashore.

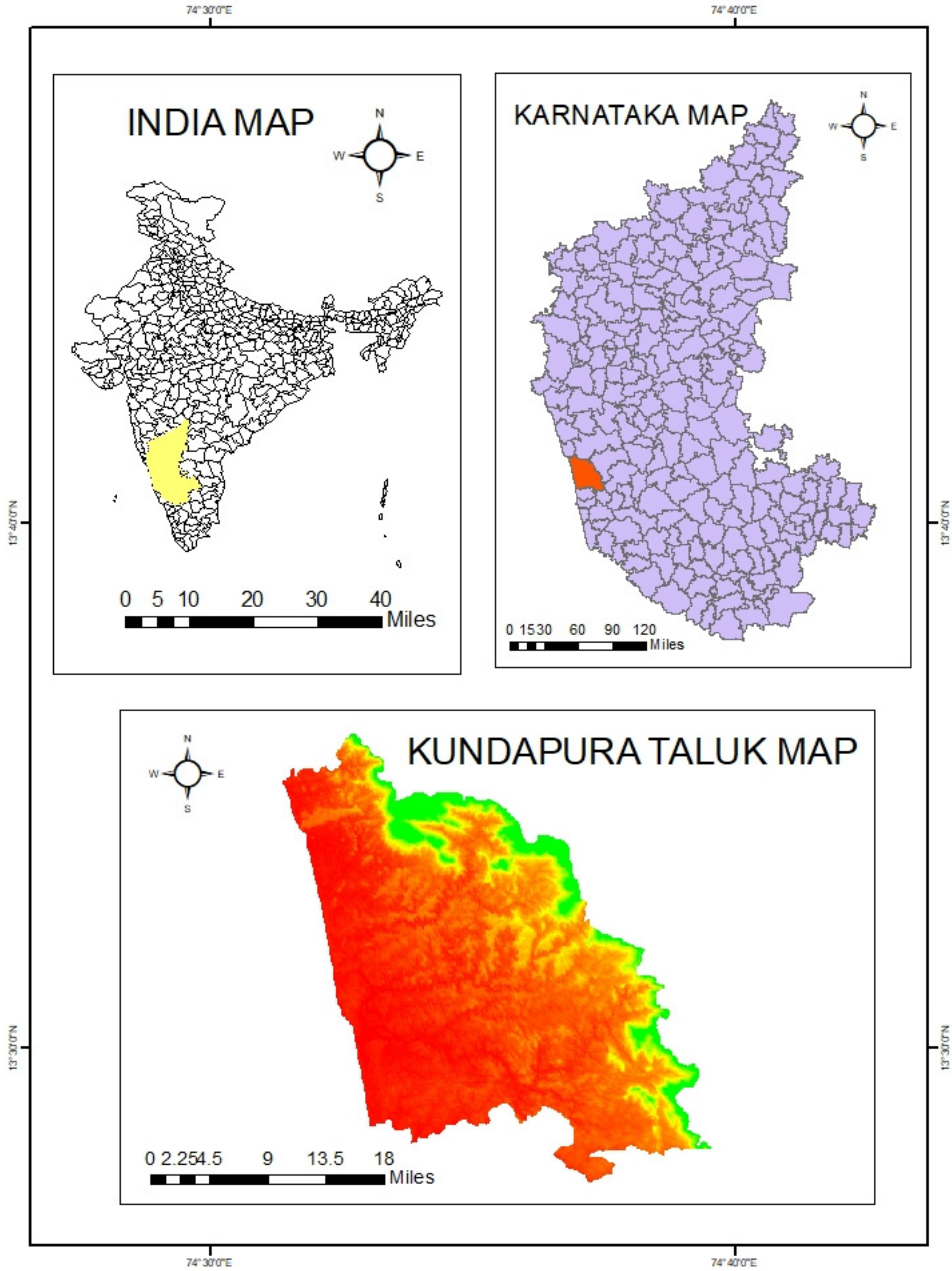

Figure 1. Location map of Kundapura Taluk.

Geology

Kundapura Taluk is a part of the Indian peninsula, which consists of geological units ranging from Achaean to Recent (Figure 2). The migmatite gneissic complex metamorphs sediments and volcanic, laterites, alluvial, sand and pebble deposits, composing the lithological assemblage of the basin. Migmatites and granodiorite-tonalitic gneiss cover an area of 57.82km^2 (3.70%) and, exposed in the northern part of the area, laterite covers 269.90km^2 (17.26%). Meta grey wake argillite covers 103.06km^2 (6.59%), meta basalt thin subordinate meta rhyolite and association covers 103.24 km^2 (6.60%), pink hornblende granite covers 187.14 km^2 (11.97%), alluvial soil covers 54.39 km^2 (3.48%), meta basalt, including thin iron stone covers 102.99 km^2 (6.59%), hornblende-biotite gneiss covers 684.35 km^2 (43.77%) and talc tremolite actinolite schist covers 0.58 km^2 (0.04%). The occurrence of pebbles, pebble beds and river sands is confined to the river courses. When compared to other taluks in the district, Kundapura is rich in its mineral wealth. The deposits of bauxite are abundant in Kundapura Taluk and, especially at Paduvare near Baindoor, they are quite significant. Lateritic and limonitic iron ore occurrences are reported in Kundapura Taluk. Accumulation of lime-shell is found in the backwaters near Kundapura. Pure white to greyish white silica sand is available along the coastal belt of Kundapura Taluk. The sand occurs as a thin layer, one to three feet in thickness, below the fine-grained brownish sand. About 15,660 T (T = Tons) of silica sand is produced annually in Kundapura Taluk.

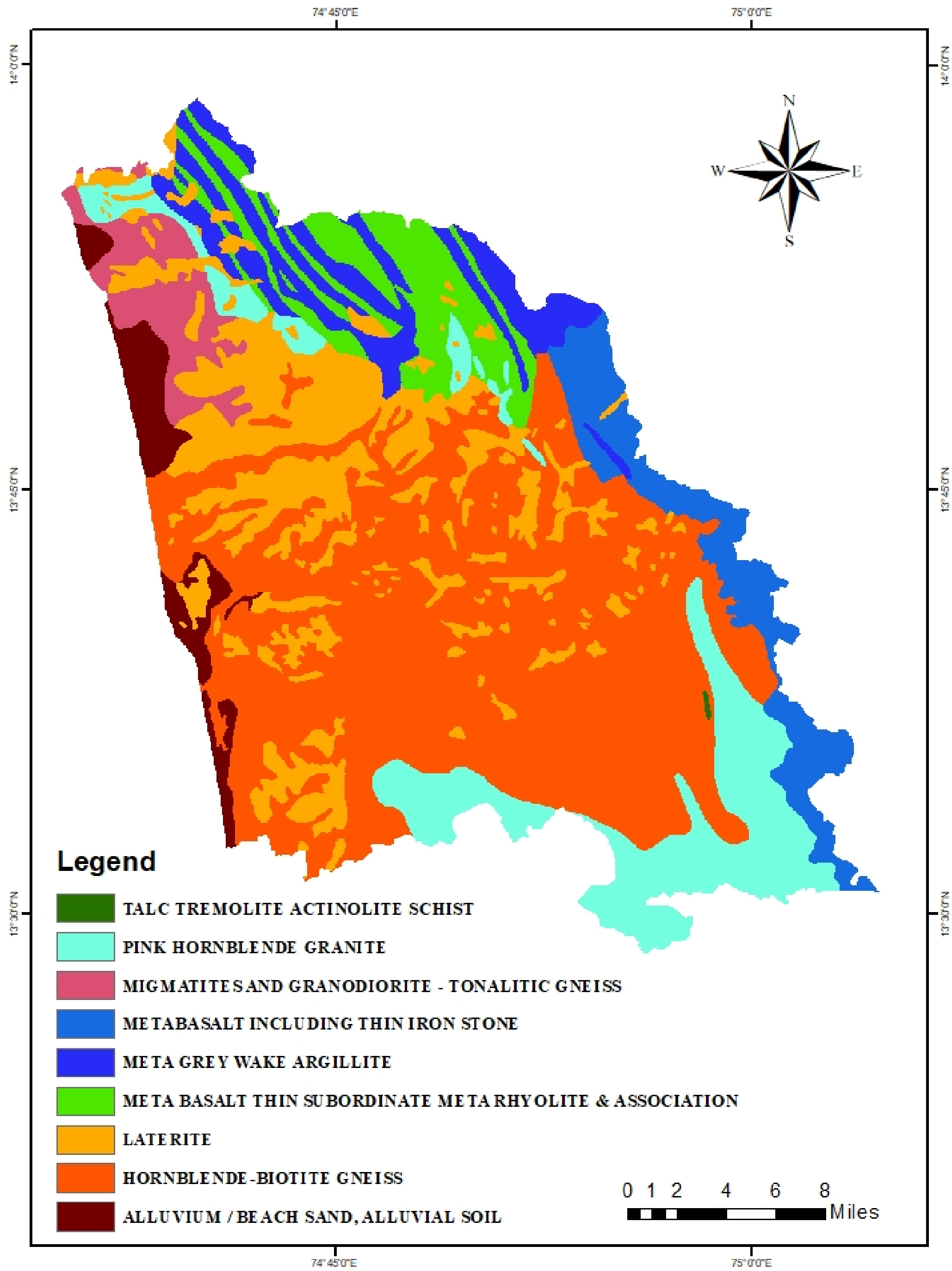

Figure 2. Geological map of Kundapura Taluk (source: KSRAC, Bengaluru).

Kundapura Taluk has eight rivulets and 125 vented dams. Varahi (Figures 3 and 4) and Gangolli are the main west flowing rivers in Kundapura Taluk. The total water body covers 43.81 sq.km of the area.

Figure 3. Varahi river basin at Siddapura, Kundapura Taluk.

Figure 4. Vottynenne estuary, where river Byndoor joins Arabian Sea and northern spit is clearly seen, Kundapura Taluk.

3. Sample Collection

The ground water samples were collected from Kundapura region. Forty water samples were collected in pre-summer 15th to 20th February 2017 and post-summer 15th to 20th May 2017 from an open well and bore well, and depth is measured from ground to water level (Table 1 and Figures 5–7). All the samples were brought to the laboratory for detailed analysis and stored at room temperature. The water samples were analyzed for various physio-chemical parameters, such as pH, electrical conductivity, total dissolved solids, total hardness, alkalinity, acidity, chlorides, dissolved oxygen (D.O) and chemical oxygen demand (C.O.D). Spatial maps are generated using Arc GIS 10.4 software (ArcGIS is a family of client software, server software, and online geographic information system services developed and maintained by Esri) and the inverse distance weighted (IDW) interpolation method [3].

Table 1. Places where water samples are collected.

SI.NO	PLACES	LATITUDE	LONGITUDE	SOURCE	SOIL TYPE	WATER DEPTH (m)	
						PRE-SUMMER	POST-SUMMER
1	KOLLUR	13.8665	74.813	open well	sandy clay	11.75	10
2	JADKAL	13.799876	74.817013	open well	sandy clay loam	9.6	8.5
3	VANDSE	13.70524	74.75719	open well	sandy clay loam	5.01	4.1
4	CHITTUR	13.73014	74.7817	open well	sandy clay loam	8.5	6.2
5	KADRADI	13.75483	74.843887	open well	sandy clay loam	7.6	5.6
6	HATTIANGADI	13.65289	74.7369	open well	sandy loam	11.6	9.6
7	TALLUR-1	13.65509	74.70763	open well	sandy loam	10.4	8.5
8	THEKKATTE-1 (S.M)	13.540604	74.688387	open well	loamy sand	8.5	7
9	ANEGUDDE	13.56994	74.70046	open well	sandy loam	4.6	3.2
10	KUMBHASHI	13.562632	74.693702	open well	sandy loam	4.9	3.4
11	KODI	13.616993	74.671623	open well	Sand	12.5	10.5
12	BEEJADI	13.577616	74.68716	open well	loamy sand	10.2	10.2
13	KUNDAPURA (B.W)	13.631596	74.68995	Bore well	sandy clay loam	6.52	5.1
14	KONI	13.60621	74.71979	open well	sandy loam	6.5	4.9
15	THEKKATTE-2	13.54983	74.701332	open well	sandy loam	7.32	5.2
16	MARGOLI	13.626152	74.732728	open well	sandy clay loam	5.96	4.2
17	MITK	13.614228	74.732674	open well	sandy clay loam	5.8	4.6
18	BASRUR	13.62998	74.735341	open well	sandy clay loam	12.5	10.5
19	HALADI	13.576383	74.862319	open well	sandy clay loam	5.2	3.9
20	AMPARU	13.64811	74.82247	open well	sandy clay loam	10.42	8.9
21	KAMALSHILE	13.73911	74.90186	open well	sandy clay loam	8.5	6.9
22	TALLUR-2	13.640716	74.704691	open well	sandy clay loam	12.1	10.2
23	AMAVASYEBAILU	13.5819	74.95825	open well	sandy clay loam	4.3	3.1
24	SHANKARNARAYANA	13.60791	74.86056	open well	sandy clay loam	4.65	3.2
25	YEDTHARE	13.917189	74.645556	open well	loamy sand	6.5	5.1
26	NAVUNDA	13.74479	74.63994	open well	loamy sand	10.5	8.5
27	SENAPURA	13.716274	74.682627	open well	sandy loam	8.5	6.2
28	KANDLUR	13.634377	74.769131	open well	sandy clay loam	8.06	7.1
29	HALLIHOLE	13.745338	74.899109	open well	sandy clay loam	8.6	6.6
30	ULLUR	13.675	74.89787	open well	sandy clay loam	12	10
31	MULLIKATTE	13.684047	74.648954	open well	Sand	11.2	9.5
32	SIDDAPURA	13.66431	74.90796	open well	sandy clay loam	12.5	10.5
33	KUNDAPURA (G.G)	13.631596	74.689995	open well	sandy clay loam	10	8.5
34	UPPUNDA	13.827688	74.649576	open well	Sand	9	7.5
35	PADUVARA	13.876185	74.602434	open well	loamy sand	10.5	8.5
36	MARVANTHE	13.723891	74.646048	open well	Sand	9.57	8.65
37	HEMMADI	13.676908	74.694092	open well	sandy loam	9.5	7.6
38	TRASI	13.692335	74.652399	open well	Sand	11.95	9.65
39	GANGOLLI	13.65149	74.664803	open well	Sand	12.9	10.4
40	HOSANGADI	13.701	74.9623	open well	Clay	9	7.3

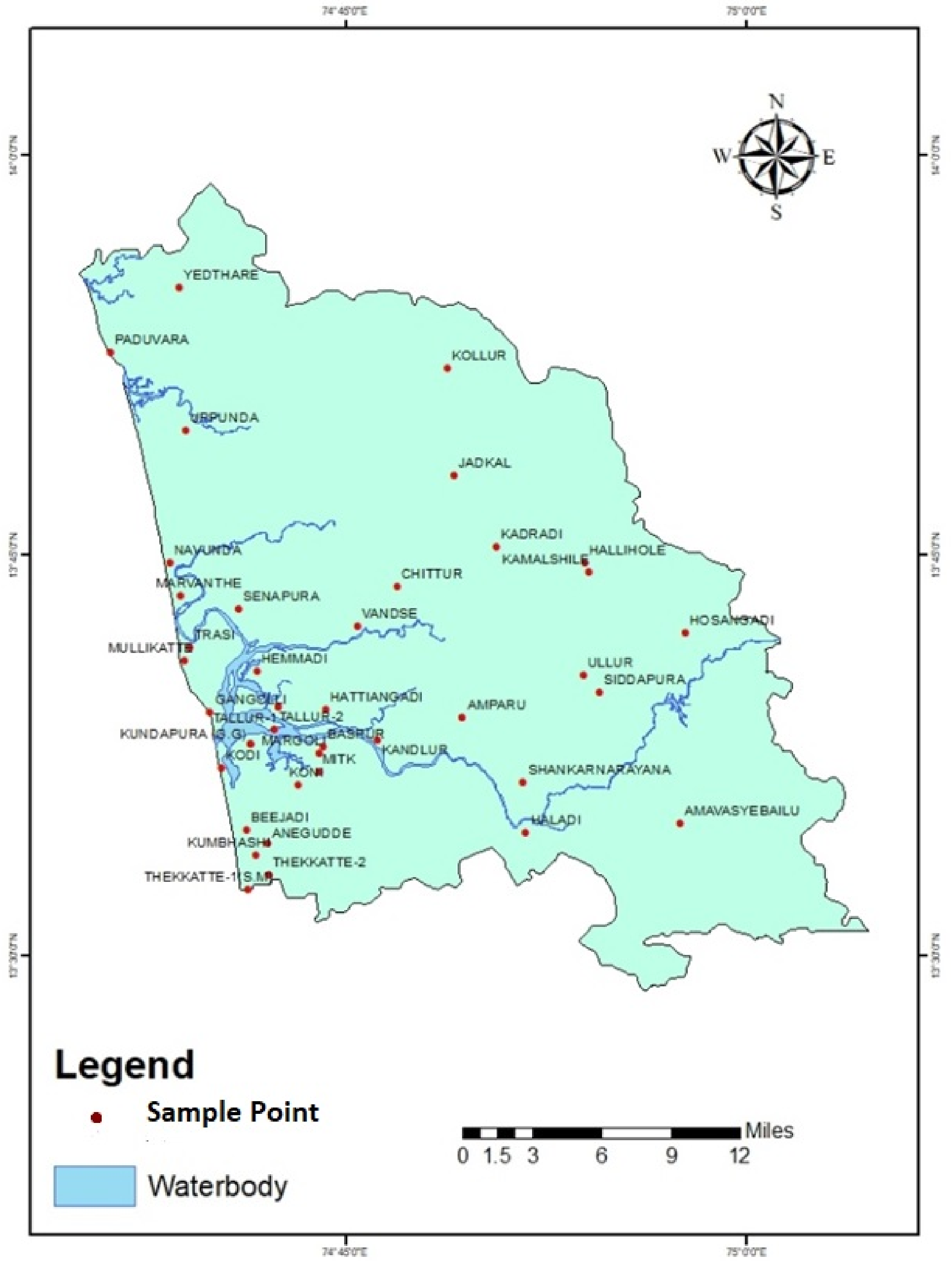

Figure 5. Ground water samples collected in Kundapura Taluk.

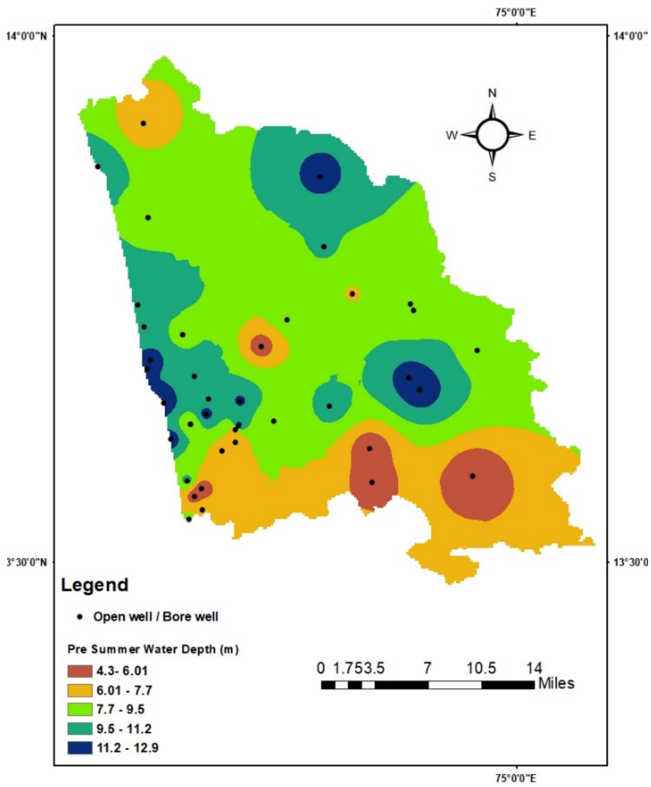

Figure 6. Pre-summer water depth (m).

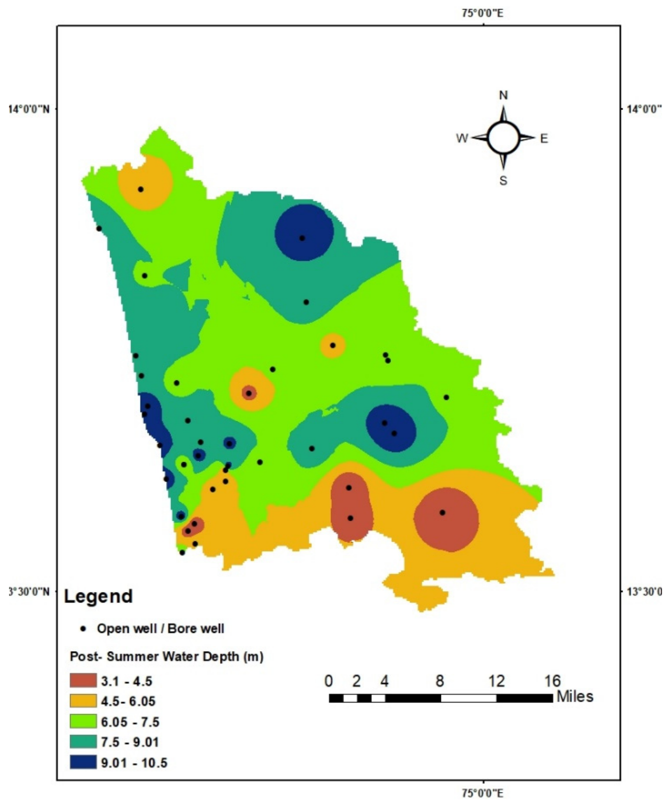

Figure 7. Post-summer water depth (m).

4. Method & Methodology

Forty different sites at Kundapura Taluk were selected in order to study the physio-chemical characteristics of ground water samples in the pre-summer and post-summer period. The samples were collected during 2017 following the standard methods prescribed for sampling. The standard methods and procedures were used for quantitative estimation of water quality parameters [16]. Nine water quality physio-chemical parameters, whose standards are prescribed by IS 10500-2012, were analyzed quantitatively in all the drinking water samples collected at Kundapura, and water quality indices of drinking water were estimated [14], collected at 40 different sites at Kundapura in the pre-summer and post-summer period, and calculated using the methods proposed by [14]. The parameters were compared according to the standard methods described in the literature (IS 10500-2012). The weighted arithmetic index method [7] was used for the calculation of the water quality index (WQI) of the water body. Further, quality rating, or sub index (qn), was calculated by the following expression. The analyzed water quality parameter with their permissible limit [5] [Indian standard Drinking water specification (IS-10500, 2012)] in Table 2 and temporal variations are shown in the form of Figures 8–16:

$$Qn = [(Vn - Vid)/(Sn - Vid)] \times 100$$

where: Qn = quality rating for the nth water quality parameter, Vn = estimated value of the nth water quality parameters of collected sample, Sn = standard permissible value of the nth water quality parameter and Vid = ideal value of the nth water quality parameter in pure water.

Table 2. Analyzed water quality parameter with their permissible limit [Indian standard Drinking water specification (IS-10500, 2012)].

SI.NO	PARAMETERS	DRINKING WATER QUALITY STANDARD	ANALYTICAL METHODS
1	pH value	6.5–8.5	pH meter
2	TDS (total dissolved solids)	500–2000 mg/L	TDS meter
3	Total alkalinity	200–600 mg/L	Titration
4	Hardness	200–600 mg/L	Titration
5	Chloride	250–1000 mg/L	Titration
6	Acidity	<200 mg/L	Titration
7	Dissolved oxygen	4–30	Titration
8	COD (chemical oxygen demand)	<250 mg/L	Titration
9	Electrical conductivity	97–1378 mmhos	Electrometric conductivity meter

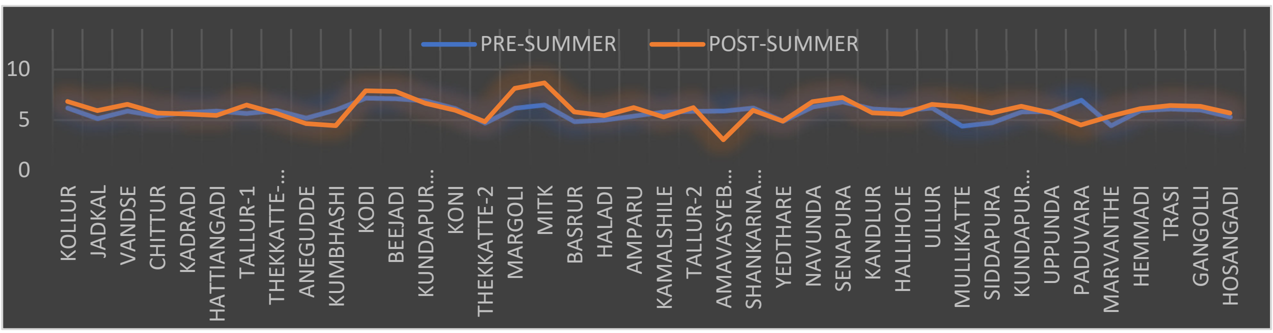

Figure 8. Temporal variation of pH test.

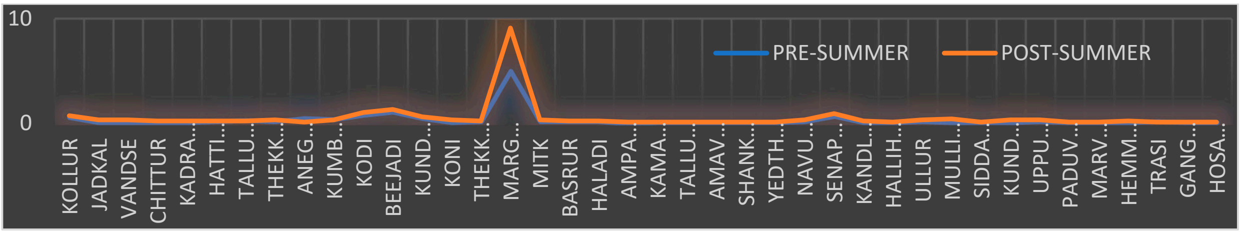

Figure 9. Temporal variation of conductivity test.

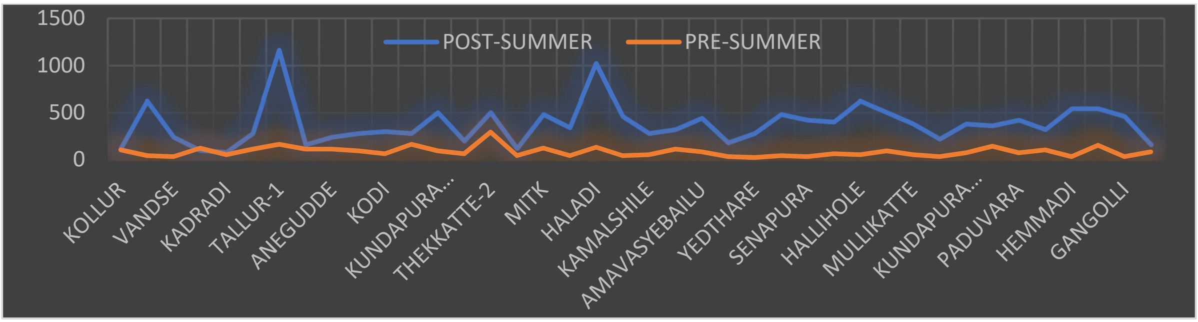

Figure 10. Temporal variation of acidity test in mg/L.

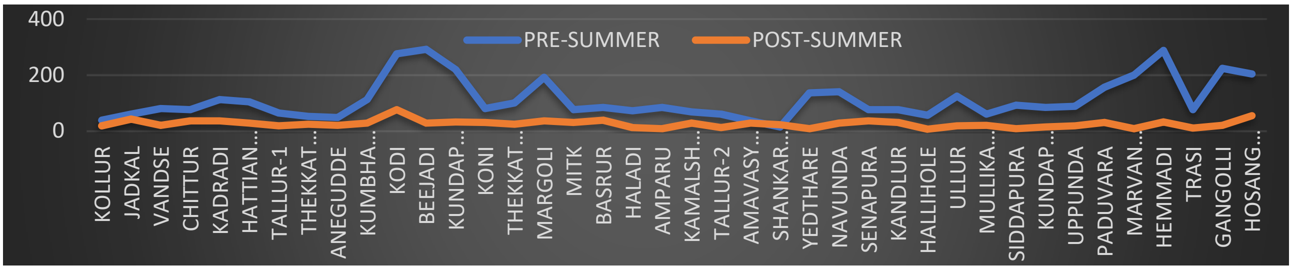

Figure 11. Temporal variation of alkalinity test in mg/L.

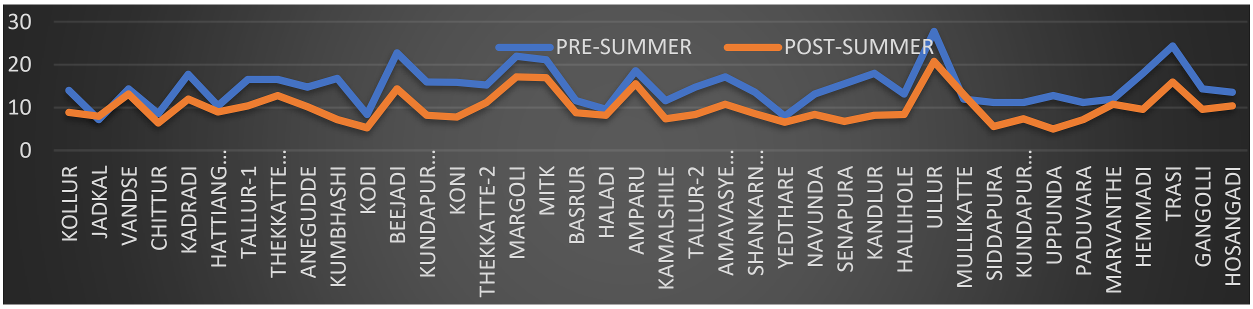

Figure 12. Temporal variation of DO test in mg/L.

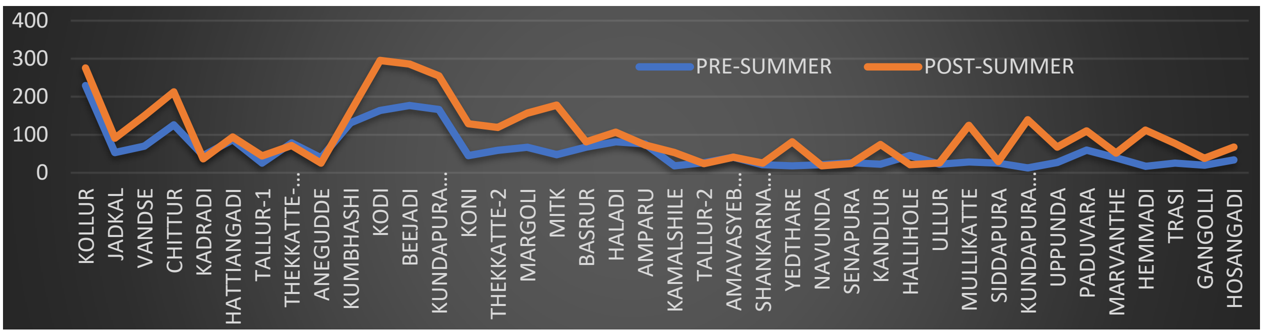

Figure 13. Temporal variation of hardness test in mg/L.

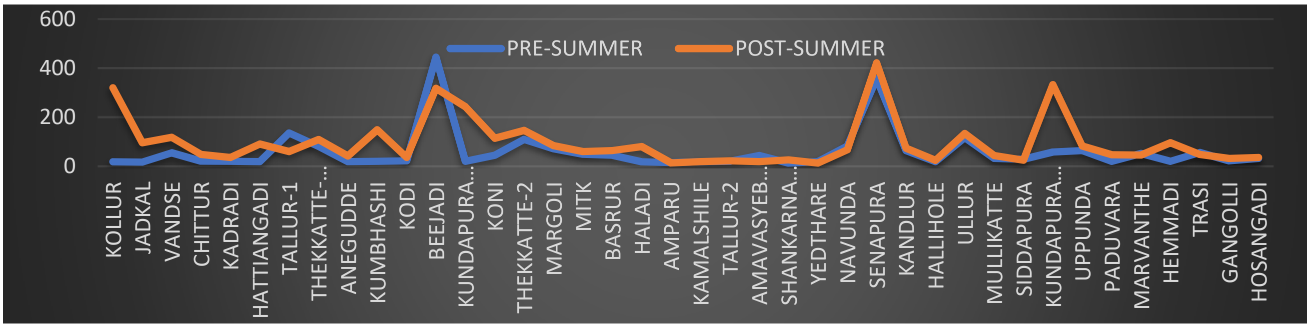

Figure 14. Temporal variation of TDS test in mg/L.

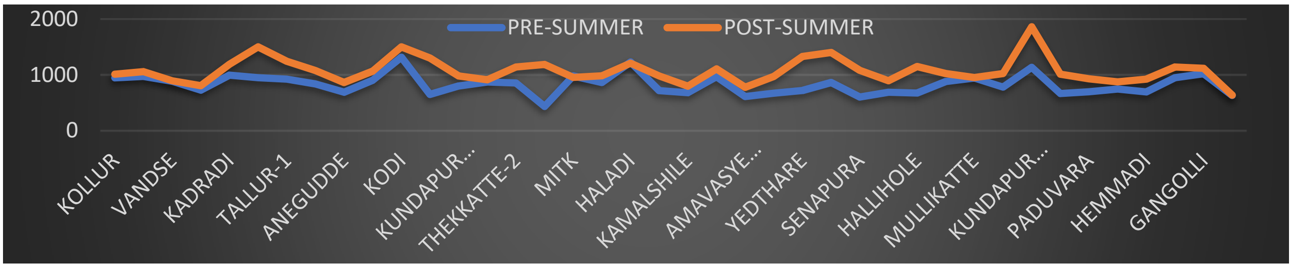

Figure 15. Temporal variation of chemical oxygen demand in mg/L.

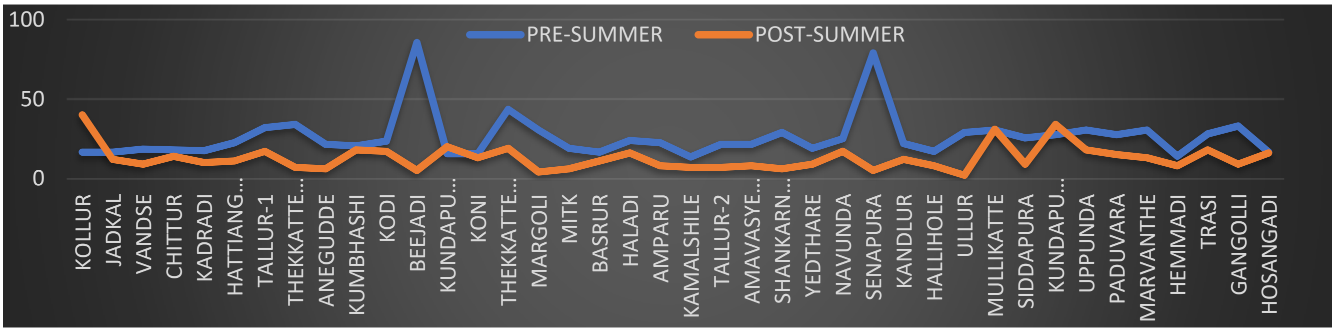

Figure 16. Temporal variation of chloride test in mg/L.

I.e., 0 for all other parameters accept the parameter pH and dissolved oxygen 7 and 14.6 mg/L, respectively. Let there be n water quality parameters and quality rating or sub index (qn) corresponding to the nth parameter, which is a number reflecting the relative of this parameter in polluted water, with respect to its standard permissible value. Unit weight was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.

$$\text{Wn} = \text{K}/\text{Sn}$$

where: Wn = unit weight for nth water quality parameter, Sn = standard permissible value of the nth water quality parameter, K = constant for proportionality.

The overall WQI was calculated by aggregating the quality rating with the unit weight linearly.

$$\text{WQI} = \sum \text{Qn Wn}/\sum \text{Wn}$$

where, Qn = quality rating of nth water quality parameter and Wn = unit weight of nth water quality parameter.

5. WQI and Status

For the purpose of the calculation of the WQI for the study area, nine water quality parameters were selected. The parameters are pH, electrical conductivity, total dissolved solids, total hardness, alkalinity, acidity, chlorides, dissolved oxygen and C.O.D. The values of these parameters are found high above and below the permissible limits in some of the samples of the study area. The higher values of these parameters would increase WQI value. The WQI values of the study area for pre-summer and post-summer samples are calculated separately. The WQI is calculated based on nine selected physiochemical parameters for all 80 samples, the values of which are shown in Tables 3 and 4. WQI standard ranges mentioned in Table 5 and estimated WQI values are shown in Table 6. Figures 17 and 18 show the spatial distribution of WQI values. These spatial maps clearly show that drastic changes in the water quality index with respect their seasons.

Table 3. Pre-summer drinking water quality parameters result.

SI.NO	PLACES	PH	EC	ACIDITY	ALKALINITY	DO	TOTAL HARDNESS	TDS	COD	CHLORIDE
1	KOLLUR	6.2	0.6	100	38	14	229.6	18	947.2	16.49
2	JADKAL	5.15	0.1	40	60	7.2	53.2	17	972.8	16.51
3	VANDSE	5.89	0.1	30	80	14.4	70	55	886.4	18.49
4	CHITTUR	5.4	0.1	120	76	8.6	126	21	726.4	17.99
5	KADRADI	5.75	0.1	50	112	17.8	44.8	20	995.2	17.49
6	HATTIANGADI	5.9	0.2	110	104	10.4	86.8	19	950.4	22.49
7	TALLUR-1	5.65	0.3	160	64	16.6	25.2	136	924.8	31.99
8	THEKKATTE-1 (S.M)	5.96	0.2	110	52	16.6	78.4	81	838.4	33.98
9	ANEGUDDE	5.2	0.5	110	48	14.8	39.2	19	689.6	21.49
10	KUMBHASHI	6	0.4	90	112	16.8	131.6	20	905.6	20.49
11	KODI	7.18	0.8	60	276	8.4	163.8	22	1318.4	23.49
12	BEEJADI	7.12	1.1	160	292	22.8	177	445	648	85.47
13	KUNDAPURA (B.W)	6.91	0.5	90	220	16	166.6	20	800	15.49
14	KONI	6.14	0.1	60	80	15.9	44.8	45	873.6	15.49
15	THEKKATTE-2	4.7	0.2	290	100	15.3	58.8	110	854.4	43.48
16	MARGOLI	6.18	5	40	192	22	67	71	433.6	30.49
17	MITK	6.5	0.2	120	76	21.2	47.6	49	982.4	18.99
18	BASRUR	4.85	0.2	40	84	11.6	67.2	45	864	16.49
19	HALADI	5	0.2	130	72	9.6	81.2	18	1232	23.91
20	AMPARU	5.4	0	40	84	18.6	75.6	15	716.8	22.49
21	KAMALSHILE	5.8	0.1	50	68	11.6	18.2	19	681.6	13.49
22	TALLUR-2	5.87	0.1	110	60	14.8	26.6	20	966.4	21.49
23	AMAVASYEBAILU	5.9	0.1	80	36	17.2	40.6	44	611.2	21.49
24	SHANKARNARAYANA	6.2	0.1	30	14	13.6	21	13	672	28.99
25	YEDTHARE	4.9	0.1	20	136	8	18.2	19	720	18.99
26	NAVUNDA	6.3	0.2	40	140	13.2	21	82	864	24.99
27	SENAPURA	6.8	0.7	30	76	15.6	26.6	357	601.6	78.97
28	KANDLUR	6.1	0.1	60	76	18	22.4	64	688	21.99
29	HALLIHOLE	5.95	0.1	50	56	13.2	44.8	19	675.2	16.99
30	ULLUR	6.2	0.2	90	124	27.8	22.4	117	880	28.99
31	MULLIKATTE	4.4	0.1	50	60	12	28	32	944	30.5
32	SIDDAPURA	4.74	0.1	30	92	11.2	25.2	29	780.8	25.49
33	KUNDAPURA (G.G)	5.82	0.1	70	84	11.2	12.6	58	1136	27.49
34	UPPUNDA	5.86	0.2	140	88	12.8	26.8	64	665	30.49
35	PADUVARA	6.97	0.1	70	156	11.2	59.4	20	697.6	27.49
36	MARVANTHE	4.45	0.1	100	200	12	39.2	52	745.6	30.49
37	HEMMADI	5.95	0.1	30	288	18	16.8	20	694.4	13.99
38	TRASI	6.1	0.2	150	76	24.4	25.2	56	950.4	27.99
39	GANGOLLI	6.01	0.1	30	224	14.4	19.6	22	1020.8	32.99
40	HOSANGADI	5.31	0.1	80	204	13.6	33.6	32	630.4	16.49

Table 4. Post-summer drinking water quality parameters result.

SI.NO	PLACES	PH	EC	ACIDITY	ALKALINITY	DO	TOTAL HARDNESS	TDS	COD	CHLORIDE
1	KOLLUR	6.8	0.7	120	18	8.9	275.8	320	1014.4	39.98
2	JADKAL	5.89	0.3	620	42	8	91	96	1059.2	11.99
3	VANDSE	6.52	0.3	240	20	13.2	149.8	118	896	8.99
4	CHITTUR	5.65	0.2	100	36	6.4	212.8	48	806.4	13.9
5	KADRADI	5.56	0.2	80	36	12	36.4	36	1190.4	9.99
6	HATTIANGADI	5.41	0.2	280	28	9	93.8	91	1503.2	10.99
7	TALLUR-1	6.45	0.2	1160	18	10.4	44	60	1244.8	16.99
8	THEKKATTE-1(S.M)	5.62	0.3	160	24	12.8	71.4	109	1078.4	6.99
9	ANEGUDDE	4.6	0.1	240	20	10.2	25.2	42	864	5.99
10	KUMBHASHI	4.4	0.3	280	28	7.2	161	149	1068.8	17.99
11	KODI	7.86	1	300	76	5.3	295.6	36	1504	16.99

Table 4. *Cont.*

SI.NO	PLACES	PH	EC	ACIDITY	ALKALINITY	DO	TOTAL HARDNESS	TDS	COD	CHLORIDE
12	BEEJADI	7.8	1.3	280	28	14.4	286	318	1302.4	4.99
13	KUNDAPURA (B.W)	6.62	0.6	500	32	8.2	254.8	243	982.4	19.99
14	KONI	5.94	0.3	200	30	7.8	128.8	114	912	12.99
15	THEKKATTE-2	4.8	0.2	500	24	11.2	119	146	1142.4	18.99
16	MARGOLI	8.1	9.1	120	36	17.2	156.8	84	1187.2	3.99
17	MITK	8.65	0.3	480	30	17	177.8	60	956	5.99
18	BASRUR	5.76	0.2	340	38	8.8	81.2	64	985.6	10.99
19	HALADI	5.4	0.2	1020	12	8.2	106.4	80	1212.8	15.99
20	AMPARU	6.2	0.1	460	8	15.6	72.8	14	982.4	7.99
21	KAMALSHILE	5.25	0.1	280	28	7.4	53.2	19	796.8	6.99
22	TALLUR-2	6.2	0.1	320	12	8.4	23.8	22	1107.2	6.99
23	AMAVASYEBAILU	3	0.1	440	28	10.8	40.6	19	779.2	7.99
24	SHANKARNARAYANA	5.92	0.1	180	22	8.6	25.2	26	974.4	5.99
25	YEDTHARE	4.85	0.1	280	8	6.6	81.2	13	1332.8	8.99
26	NAVUNDA	6.78	0.3	480	28	8.4	18.2	67	1404.8	16.99
27	SENAPURA	7.2	0.9	420	36	6.8	23.8	422	1081.6	4.99
28	KANDLUR	5.67	0.2	400	30	8.2	74.2	74	896	11.99
29	HALLIHOLE	5.55	0.1	620	6	8.4	210	24	1152	7.99
30	ULLUR	6.52	0.3	500	18	20.8	25.5	134	1024	1.99
31	MULLIKATTE	6.28	0.4	380	20	13	124.6	44	953.6	30.99
32	SIDDAPURA	5.65	0.1	220	8	5.6	29.4	25	1024	8.99
33	KUNDAPURA (G.G)	6.32	0.3	380	14	7.4	139.6	333	1865	33.98
34	UPPUNDA	5.65	0.3	360	18	5	67.2	82	1014.4	17.99
35	PADUVARA	4.47	0.1	420	30	7.2	110	47	931.2	14.99
36	MARVANTHE	5.33	0.1	320	8	10.8	51.8	46	875.2	12.99
37	HEMMADI	6.08	0.2	540	32	9.6	112	96	924.8	7.99
38	TRASI	6.4	0.1	540	10	16	77	48	1142.4	17.99
39	GANGOLLI	6.32	0.1	460	20	9.6	37.8	32	1120.8	8.99
40	HOSANGADI	5.65	0.1	160	54	10.4	67.2	36	636.8	15.99

Table 5. The ranges of WQI, the corresponding status of water quality and their possible uses.

Sl.No	WQI	Status	Possible Usages
1	0–25	Excellent	Drinking, Irrigation and Industrial
2	25–50	Good	Domestic, Irrigation and Industrial
3	51–75	Fair	Irrigation and Industrial
4	76–100	Poor	Irrigation
5	101–150	Very Poor	Restricted use for Irrigation
6	Above 150	Unfit for Drinking	Proper treatment required before use

Table 6. Estimated results of water quality indices at all sampling locations.

Sample ID	Pre-Summer	Post-Summer
	WQI	WQI
1	0.244028006	118.0822
2	0.250289919	153.6957
3	0.248912476	109.2059
4	0.229324589	84.43725
5	0.254388771	109.1039
6	0.245428233	154.7662
7	0.271681197	219.0843
8	0.254846296	110.3156
9	0.23976091	92.67013
10	0.243258229	117.6524
11	0.244297824	172.2654
12	0.259989301	160.4354

Table 6. *Cont.*

Sample ID	Pre-Summer	Post-Summer
	WQI	WQI
13	0.224145702	147.1545
14	0.249816091	104.2725
15	0.266712479	144.6846
16	0.198521863	129.1174
17	0.260596689	145.7288
18	0.248460444	119.8622
19	0.266322613	199.7046
20	0.233330555	129.8898
21	0.229595065	94.69791
22	0.25685119	127.661
23	0.23530844	95.35414
24	0.231558485	102.8062
25	0.221382828	135.5881
26	0.246154944	171.0533
27	0.268981405	153.2841
28	0.241948091	117.9586
29	0.229310839	158.1555
30	0.266840805	140.9945
31	0.260911626	123.0504
32	0.239208785	109.3685
33	0.264788591	206.3175
34	0.238563103	124.1805
35	0.220473474	116.0478
36	0.232881804	105.1779
37	0.214158486	136.411
38	0.265952495	152.3485
39	0.24356991	142.7952
40	0.21563819	73.59726

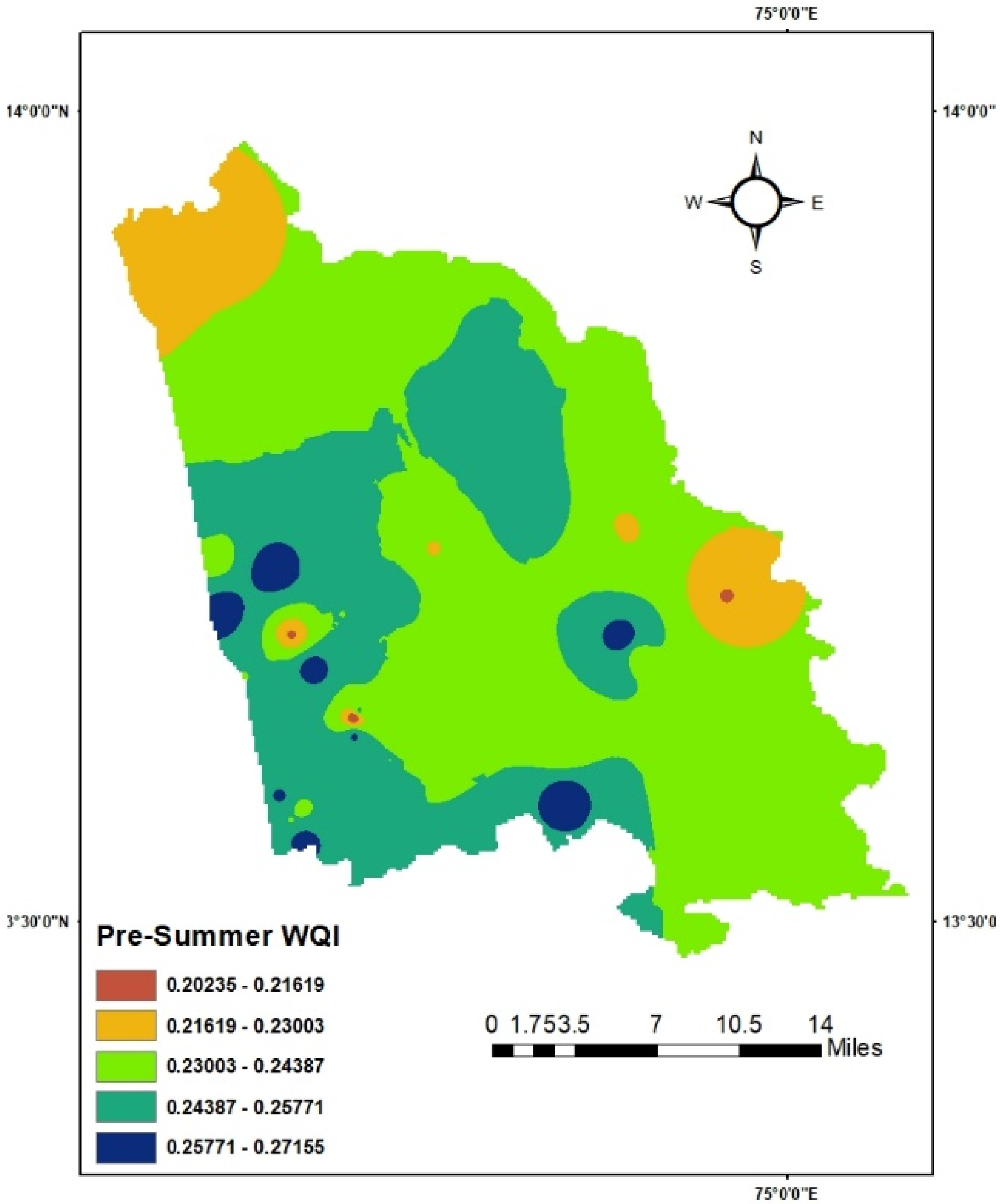

Figure 17. Pre-summer WQI of Kundapura Taluk.

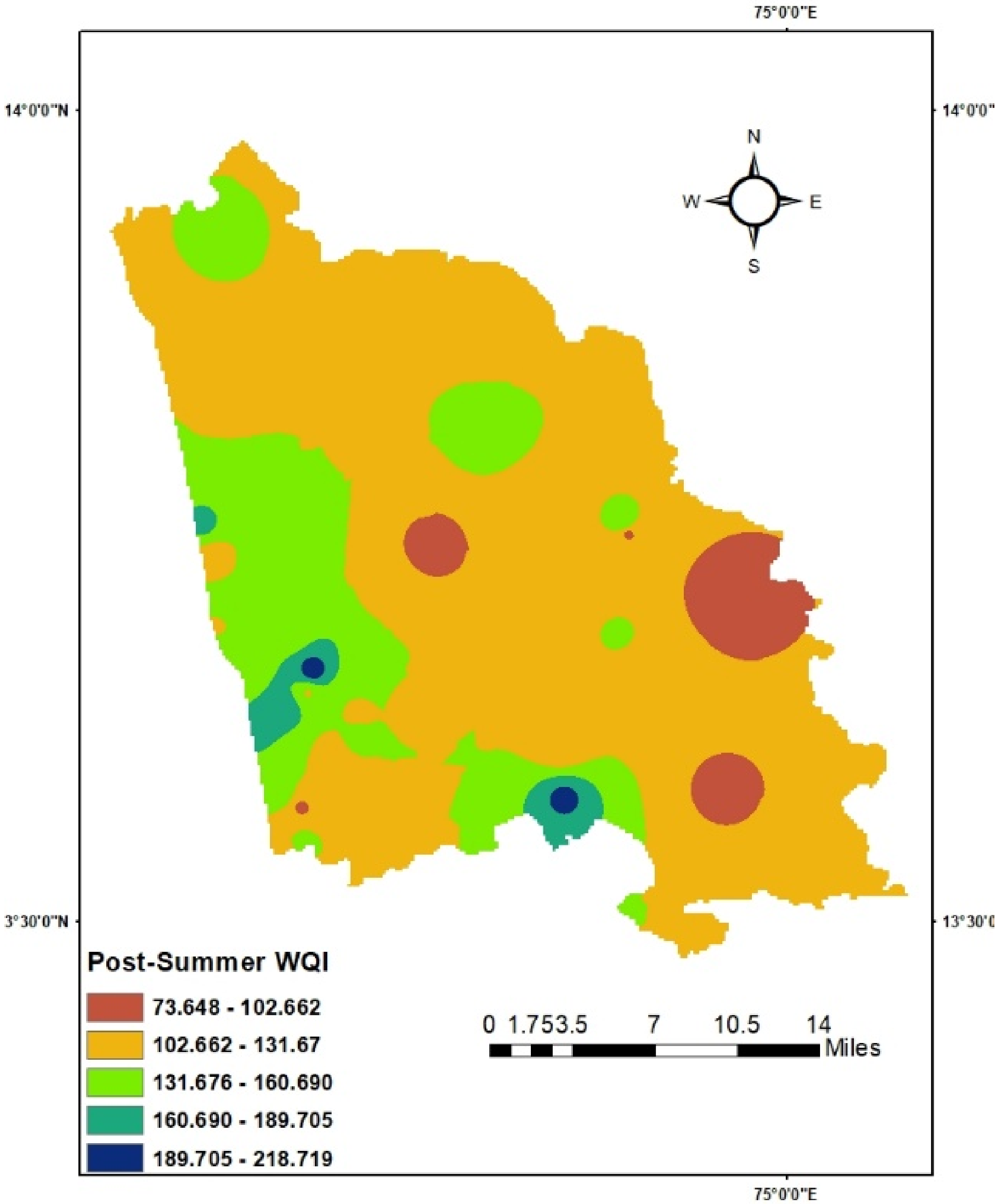

Figure 18. Post-summer WQI of Kundapura Taluk.

6. Result and Discussion

- ➢ The regional research includes temporal details about inflows, outflows, and improvements storage system-wide, as well as in selected aquifer system sub-regions.
- ➢ According to water quality indices results from pre-summer, all location water samples are drinkable and all samples fell within the 0–25 range, which means the quality is outstanding, and can be used for drinking/potable, agriculture and industrial purposes. During the post-summer period, Hosangadi has a fair water status and can only be used for irrigation and industrial purposes. Locations Chittur, Anegudde, Kamalashile and Amavasyebailu indicate 84.43725, 92.67013, 94.69791 and 95.35414 values, respectively, suggesting that the following regions have a poor water status and water can

only be used for irrigation. The remaining locations are classified as very poor to unfit for drinking, which means they cannot be used for irrigation or drinking. Before we could use these waters, they needed to be adequately handled.

- ➢ The analysis of ground water samples from different criteria shows that ground water in the majority of the research area is chemically safe for drinking.
- ➢ Water samples contain low pH in some areas, such as Amavasyebailu and Ullur (these areas are geologically slopy and are covered with gneissic rocks), and high pH in MITK and Margoli (these areas near to the coast and water bodies), during the post-summer season.
- ➢ Hardness was within the permissible limit in Kundapura region. Hence, water samples are considered as a soft water. Water with a high calcium content is unsuitable for washing or bathing and can cause gastro-intestinal diseases and stone formation.
- ➢ TDS concentrations in Kundapura Taluk is within the potable range.
- ➢ Alkalinity amounts were below reasonable limits in areas such as Maravante, Kundapura, Kodi, Beejadi and Hemmadi. These are the places near to the coast, where salinity intrusion is higher.
- ➢ During the pre-summer season, the acid content of water is below the permitted level. High levels of acidity in drinking water cause dehydration and diarrhea, as well as secondary hyperthyroidism and bone degradation.
- ➢ The dissolved oxygen concentration in all of the water samples is below the allowable range.
- ➢ For water samples with a high COD content but low electrical conductivity and chloride content, there is a need to use methods such as reverse osmosis.
- ➢ To purify the water, water purifying plants, such as lotus, yellow iris, dwarf cattail, water poppy, and Sagittarian montevidensis, can be planted in the vicinity of polluted water.
- ➢ The results of this study will be used to predict the hydrologic reactions of the aquifer system to potential shifts in anthropogenic and natural pressures to the greatest degree possible.
- ➢ Pre-summer and post-summer values vary for a number of physio-chemical parameters because of the cone of depression saltwater intrusion prevalent in Kundapura Taluk. The Kundapura coast experiences more saline intrusion in post-summer than in pre-summer, according to the present study. During the post-summer period, places such as Thrasi, Maravanthe, Gangolli and Kodi face more problems in drinking water. General control measures for saltwater intrusion are used to: keep outdoor watering to a minimum; to increase fresh ground water; to refill, for example, by using surface ponds to reduce surface runoff and to improve infiltration rates; to create wells that do not penetrate deeper than needed below sea level; to multiply well systems; to pump wells alternative; and to size pumps at lower pumping rates. Kundapura Taluk belongs to a coastal region, where high salinity is observed due to the severe tidal effects of saltwater intrusion. High saline comes near to coast of Kundapura Taluk. In such areas, saline soils have a detrimental impact on urban structures, primarily by causing land subsidence, corrosion and adversely affecting the quality of ground water.

7. Conclusions

The regional analysis has provided temporal information about the inflows, outflows and changes in storage system-wide, and in selected sub-regions of the aquifer system. Assessment of ground water samples from various parameters indicates that ground water, in most parts of the study area, is chemically suitable for drinking purposes. Pre-summer and post-summer values show a distinction in numerous physio-chemical parameters. During the post-summer, the water level decreases mechanically, and water exploration is more, and result causes the cone of depression. Due to this intrusion of saltwater in well is common in Kundapura taluk, so water loses its quality. Thus, pre-treatment is additional necessary in post-summer.

Water quality parameters, such as pH, electrical conductivity, total dissolved solids, total hardness, alkalinity, acidity, chlorides, dissolved oxygen, and C.O.D., are within the permissible limit as prescribed by Indian standards. The completed WQI indicates that ground water, in most parts of the study area, is chemically suitable for drinking purposes, whereas study results of different seasons reveal changes in the WQI. The WQI shows that water of pre-summer seasons is suitable for drinking purposes, whereas during the post-summer season, the WQI increases due to the over-exploration of water. This eventually leads to saltwater intrusion and creates a cone of depression, making the water more unfit. Further, we used these results for the mapping of saltwater intrusion and salinity mapping for Kundapura Taluk, and generated a soil salinity model.

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