

SPATIAL DISTRIBUTION OF GROUNDWATER QUALITY BOUNDARIES ENCOMPASSING SANTHABOMMALI MANDAL SRIKAKULAM DISTRICT ANDHRA PRADESH A GIS APPROACH

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Abstract

The most important common resource needed to meet different people all across the world, especially in similar locations, is groundwater. The asset cannot be used or directed with certainty unless the possibility of groundwater is identified. The assessment shown here makes use of geographic information system (GIS) advancement to portray drinking water quality and improvement using data from combined evaluation of water tests acquired from the evaluation district. In this paper, we will examine the distinct geological highlights of the Santhabommali catchment area using cooperatively organised types of ground water-related information. Using ArcGIS 10.3 programming, this information is used to interpret a guide and digitise it. Spatial spread aids for pH, TDS, TH, Cl, HCO₃, SO₄, NO₃, Ca, Mg, Na, F, and K have been created using GIS shaping frameworks. With the use of this book, one can easily examine the water that is present at various locations in this area, and it also aids in deciding what actions should be taken to improve the quality and use of the water. In order to have an understanding of the current groundwater quality, the physical-blend works out as intended were stood apart from the standard oversight views as recommended by the World Wellbeing Association (WHO) for drinking and general thriving.

Keywords: ArcGIS, Groundwater, Quality maps and Chemical analysis

Introduction

Hydrogeochemistry topical guides will be improved using GIS programming [1]. The thematic guides were produced using a spatial exploration tool and ArcGIS 10.3 programming. depicts the geographical circulation of border maps for water quality. The development of water on, above, and beneath the surface of the world is constant. Water is reused throughout the ground and gains several benefits in the process. Water quality changes with the seasons, the types of rock and soil it passes through, and where it is located [2]. Common cycles are typically what affect water quality [3]. For instance, even in the absence of human activity or environmental contamination, water flowing through subterranean shakes and soils may contain common poisons [4]. In addition to the influence of nature, human activity, such as the disposal of open waste, also pollutes water. (<http://water.usgs.gov/edu/earthgwaquifer.html>). The numerous Physio-Chemical characteristics are typically used to describe the quality of groundwater [5]. These borders frequently shift as a result of various pollution types, sporadic vacillation, groundwater extraction, etc. [6]. In order to prevent groundwater contamination and maintain control over the specialists who produce pollution [7], a constant monitoring of the groundwater becomes necessary. This section of the investigation aims to examine the nature of the groundwater water supply system and forecast changes in water quality and level in the Santhabommali catchment area. Water is synthesised from many components that occur as individual particles or particles. The science of groundwater's key components and artificially linked qualities has been clarified in the current field of study [9]. For this science, 110 examples from area 110 of the investigation zone were acquired and broken down into test information [10]. Essentially, the artificially associated qualities, such as total dissolved solids (TDS), total hardness (TH), and hydrogen particle action (pH), [11]. The cations that have been determined to be relevant are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate (HCO_3), chloride (Cl), fluoride (F), and nitrate (NO_3) [12]. Electrical conductivity and other parameters adjusting traditional hydrochemical methods are also used. Also broken down for two seasons is sulphate (SO_4). Groundwater quality metrics were obtained through the addition of a conventional Inverse Distance Weighted (IDW) strategy [13].

2. Material and Methods

Water samples from 34 Villages (131 samples) collected from bore wells, dugwells and tube wells namely, Maruvada, Marripadu, Yamalapeta, Meghavaram, Kapugodeyavalasa, Vadditandra, Antlavaram, Narasapuram, Jonnalapadu, Kakarapalle, Govindapuram, Godalam, Kollipadu, Borubhadra, Kurmanadhapuram, Khaspanaupada, Brundavanam, Kaseepuram, Chinnatungam, Dandugopalapuram, Tallavalasa, Kotapadu, Pothunaidupeta, Santhabommali, Palathalagam, Seepuram, Malagam, Uddandapalem, Umilada, Bhavanapadu (Mulapeta), Ijjuvaram, Akasalakkavaram, RunkuHanumanthapuram, and Siddibeharakothuru.

The investigation region is located from $18^{\circ}26'40''$ to $18^{\circ}35'12''$ North Latitude and $84^{\circ}10'40''$ to $84^{\circ}23'28''$ East Longitude. The region can be found in and around the mandal of Santhabommali, as well as in some of its neighbouring villages, in the Srikakulam District of Andhra Pradesh (Figure. 1). Ijjuvaram, Seepuram, Umilada, and Kotapadu are four locations in the study area where water samples were taken from an open well. The Santhabommali catchment area's 34 sampling sites are included in the study. The appropriateness of groundwater for drinking and irrigation purposes has been assessed at various places throughout the research area using the

technique given in the preceding chapter. The results are reported in several sections. The study area's geographic map is depicted in Figure 1 and Tables 1(a) and 1(b), along with sampling stations.

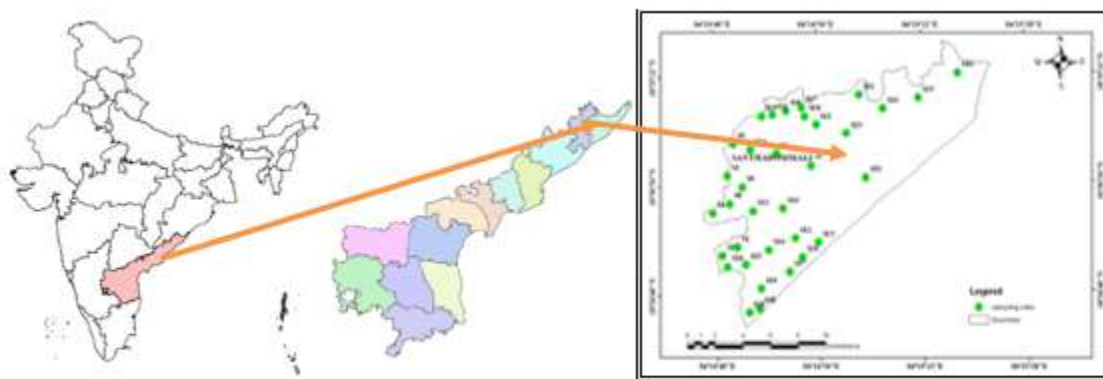


Figure 1: shows the location map of the study area with sampling stations.

Table 1(a): Comparison of Pre monsoon and Post Monsoon of 2022

Sampling Site	pH		Conductivity		TDS		HCO ₃		Cl		F	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S1	8.01	7.45	483	410	309	262	110	45	80	50	0.28	0.21
S2	8.1	7.8	572	588	366	357	250	40	35.46	60	0.43	0.1
S3	7.6	7.3	316	543	202.4	348	120	60	20	60	0.09	0.4
S4	6.5	7.9	812	581	519	371.84	244	140	113	62	0.04	0.2
S5	7.7	8	388	449	248	287.36	152	51	31.9	60	0.11	0.4
S6	8.1	8.1	622	690	398	442	105	60	57	100	0.16	0.13
S7	8.5	8.2	1203	954	736	610.56	183	129	244.6	130	0.23	0.9
S8	8.1	7.9	1840	1130	1177	723	286	190	379	140	0.46	0.1
S9	8.0	8.2	530	1320	399	844.8	110	0.028	80	122	0.34	0.6
S10	8.0	8	246	683	157	437.12	73.2	65	32	76	0.12	1.3
S11	8.2	7.3	1224	696	783	445	250	140	230	57	0.25	0.4
S12	8.3	7.8	613	722	392	462	183	100	56	82	0.14	0.3
S13	8.3	8	575	683	368	437.12	225	65	42	76	0.17	1.3
S14	8.3	7.9	1211	1559	755	998	240	280	170	130	0.24	0.4

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S15	8.0	7.7	450	739	288	473	73.2	153	102.8	102	0.22	0.6
S16	8.2	7.6	377	389	241	248.96	134	1.3	32	70	0.29	0.42
S17	8.0	8.1	554	439	354	280.96	115	70	56	36	0.11	0.81
S18	8.5	8.1	1760	2025	1126	1296	280	130	186	500	0.25	0.2
S19	8.1	8.6	820	1657	525	1060	219.6	300	120	170	0.26	0.16
S20	8.7	8.5	2784	1330	1781	851.2	463	135	280	165	0.24	0.8
S21	8.1	8.7	1000	1187	640	759.68	128	236	241	108	0.16	0.78
S22	7.7	8	388	449	248	287.36	152	51	31.9	60	0.11	0.4
S23	8.1	8.1	622	690	398	442	105	60	57	100	0.16	0.13
S24	8.5	8.2	1203	954	736	610.56	183	129	244.6	130	0.23	0.9
S25	8.1	7.9	1840	1130	1177	723	286	190	379	140	0.46	0.1
S26	7.8	8.1	487	993	318	635.2	122	120	67.4	130	0.28	0.1
S27	8.1	7.7	1208	1847	773	118.02	213	235	226	310	0.68	1.01
S28	8.3	8.1	1593	438	1019	280.32	207	92	315.5	30	0.31	0.1
S29	8.1	8.1	1878	391	1201	250.24	415	52	294	50	0.21	0.4
S30	8.7	7.8	894	667	572	426.88	204	120	120	100	0.28	0.1
S31	8.1	7.6	3301	970	2112	620.8	781	240	471	118	0.35	0.1
S32	8.1	8.9	696	726	445	464.64	173	100	127	120	0.01	0.3
S33	8.7	8.2	799	687	511	439.68	291	104	81.5	107	0.14	0.1
S34	8.1	8.2	820	755	525	387.2	219.6	140	120	50	0.22	0.1

Table 1(b): Comparison of Pre monsoon and Post monsoon of 2022

Sampling Site	NO ₃		SO ₄		Na		K		Ca		Mg		TH	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
S1	1.86	0.8	278	48	62	64	58	0.8	22	8	78	52	100	60
S2	14.2	4.2	14	72	37.9	55	31.2	3	44	40	111	80	155	120
S3	0.62	11.34	14	49	19	144	1.17	2.34	38	48	72	112	110	160
S4	18.6	4.4	24	31	65.5	28.6	0.78	14	84	24	181	176	265	200
S5	31	13	29	86	127	53.8	1.56	24	120	64	205	256	325	320
S6	129	51	33	60	261	113	104	2.73	52	40	68	160	120	200
S7	10.54	7	32	130	43.2	157	3.51	18	52	40	98	300	150	340
S8	43.4	16	52	144	121	135.5	30	14.4	72	144	233	456	305	600

S9	1.24	18.2	46	249	43	188	23.79	2.7	38	32	102	168	140	200
S10	12.4	12.8	10	76.8	18.63	48	8.58	1.56	18	40	47	100	65	140
S11	13.6	4.2	46	53	179	60	3.12	1.6	20	48	200	132	220	180
S12	62	8.4	12	86	66.7	96	15.6	2.3	30	24	105	96	135	120
S13	25.4	12.8	7	76.8	36.8	48	29.64	1.56	38	40	157	100	195	140
S14	48.36	17	90	182	147	110	12	35	60	112	210	368	270	480
S15	9.92	3.4	10	44	59.3	116	5.46	25	10	8	70	72	80	80
S16	62	5.6	11	57	20.93	21	14.43	0.39	38	24	87	136	125	160
S17	60	3.64	35	57	57.73	21	6.24	10	42	48	118	252	160	300
S18	326	6.02	73	10.1	188.6	215	206.7	160	58	40	137	280	195	320
S19	12.4	18	38	154	109	131	9.77	3.1	44	120	116	400	160	520
S20	409.2	25.7	178	152	361	129	40.2	42	156	16	379	304	535	320
S21	18.6	0.69	32	89	119.6	31	23.2	32	58	64	142	476	200	540
S22	6.2	0.03	5	60	23.69	25	0.69	1.6	32	40	108	80	140	120
S23	2.8	0.6	25	374	89	34	14	0.8	24	48	76	192	100	240
S24	31	13	29	86	127	53.8	1.56	24	120	64	205	256	325	320
S25	129	51	33	60	261	113	104	2.73	52	40	68	160	120	200
S26	10.54	7	32	130	43.2	157	3.51	18	52	40	98	300	150	340
S27	43.4	16	52	144	121	135.5	30	14.4	72	144	233	456	305	600
S28	22.9	8.7	134	51	207	66.4	140	7.8	56	16	114	84	170	100
S29	57	4.3	126	41	191	39	76.8	2.3	96	16	324	104	420	120
S30	49	2	49	49	70	89	19.5	28	86	32	184	128	270	160
S31	86	10	163	60	492	47	1.95	27.6	166	40	414	700	580	740
S32	1.86	6	17	52	23.4	42	3.12	20	74	64	221	176	295	240
S33	0.62	8	24	78	122	48	10.14	2.3	28	56	92	164	120	220
S34	12.4	45	38	65	109	80	9.77	80	44	16	116	144	160	160

3. Results and Discussions

Statistical Seasonality for 2022

pH

Pre-monsoon pH ranges from 6.49 to 8.67, whereas post-monsoon pH ranges from 7.12 to 8.64. The majority of the study's sites exhibit an alkaline inclination. Pre-monsoon pH readings at 58% of sample stations are higher above the ideal range (6.5-8.5). In the Kaseepuram, Yamalapeta, Antlavaram, and Kollipadu region, these are appropriate for drinking (6.5 to 8.5) and not suitable for drinking (less than 6.49 and greater than 8.67). The regional distribution of the pH water quality measure is depicted in Figures 2(a) and 2(b).

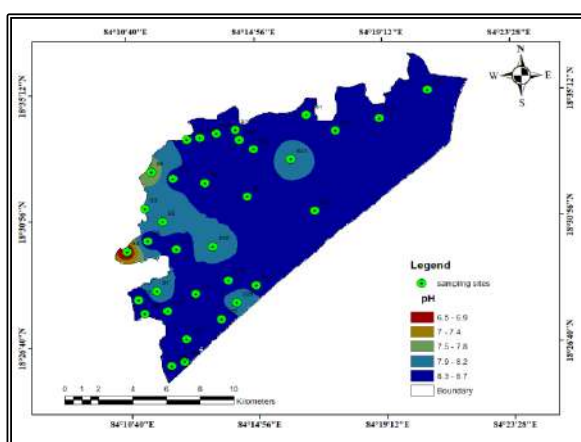


Figure 2(a): pH Post monsoon

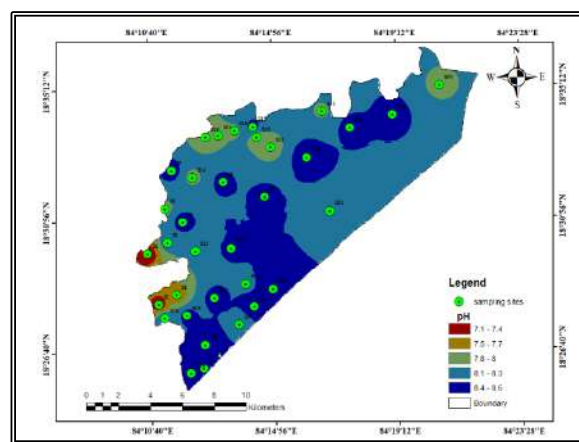


Figure: 2(b): pH Pre monsoon

Electrical Conductivity

From 512 to 1862 s/min before the monsoon and from 330 to 2025 s/min after the monsoon, electrical conductivity was recorded. There have been reported in the areas of Kollipadu, Marripadu, Kuramanadhapuram, Brundavanam, and Pothunaidupeta. The regional distribution of the water quality indicator total hardness in both the pre- and post-monsoon is depicted in Figures 3(a) and 3(b).

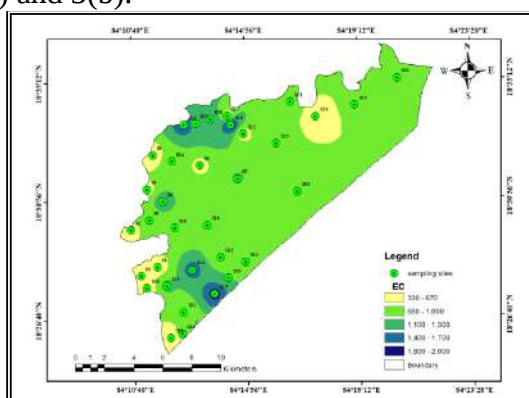


Figure 3(a): EC Pre monsoon

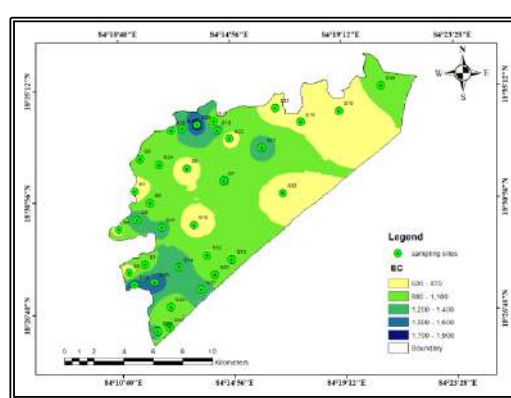


Figure 3(b): EC Post monsoon

Total Dissolved Solids

The range of total dissolved solids during the pre-monsoon was 112 to 842 mg/l, while during the post-monsoon, it was 118.02 to 1296 mg/l. These are best suited for consuming concentrations that are below 500 mg/l and within the range of 500 to 1500 mg/l. Additionally, the Aakashalakhavaram, Antlavaram, Mulapeta, and Kapugodhayavalasa are found to have water that is unfit for drinking if the concentration is above 1500 mg/l. The spatial distribution of the water quality metric TDS in both pre- and post-monsoon is depicted in Figures 4(a) and 4(b).

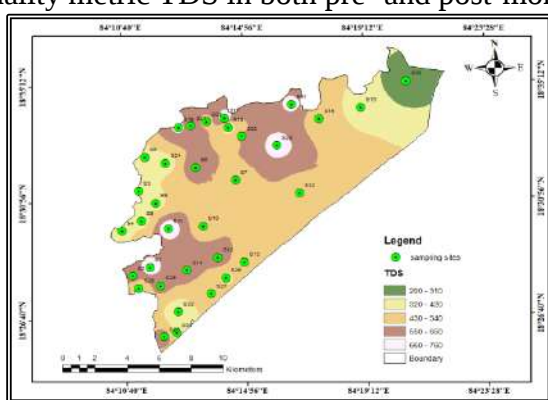


Figure 4(a): TDS Pre monsoon

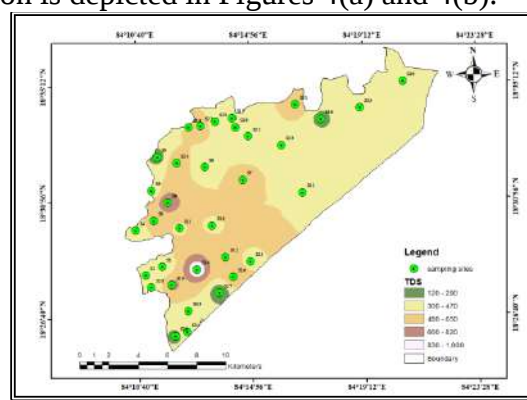


Figure 4(b): TDS Post monsoon

Total Hardness

During the pre-monsoon season, total hardness was found to range from 54 to 512 mg/l at all sites, while during the post-monsoon season, it ranged from 60 to 740 mg/l. Many stations have hardness levels that are significantly higher than the BIS recommended threshold of 300 mg/l throughout the pre- and post-monsoon seasons. The health of people is not negatively impacted by hardness. Water with a hardness of over 300 mg/l may lead to scale buildup in the water delivery system and increased soap usage. The areas of Chinnathungam, Dandugopalapuram, Godalam, and Ijjuvaram are most suited for less than ideal drinking values (600 mg/l), permitted drinking values (between 600 and 1000 mg/l), and unsuitable drinking values (more than 1000 mg/l). The regional distribution of the water quality indicator total hardness in both the pre- and post-monsoon is depicted in Figures 5(a) and 5(b). The health of people is not negatively impacted by hardness. Water with a hardness of over 300 mg/l may lead to scale buildup in the water delivery system and increased soap usage.

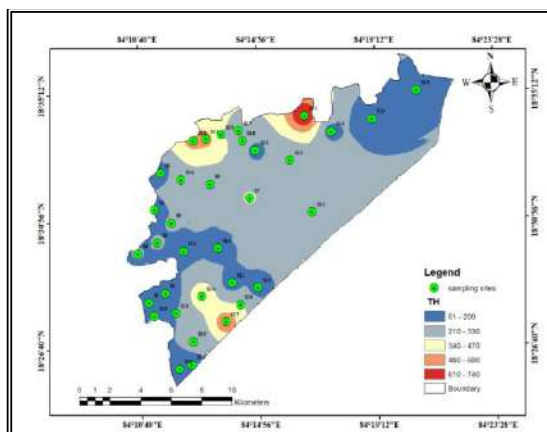
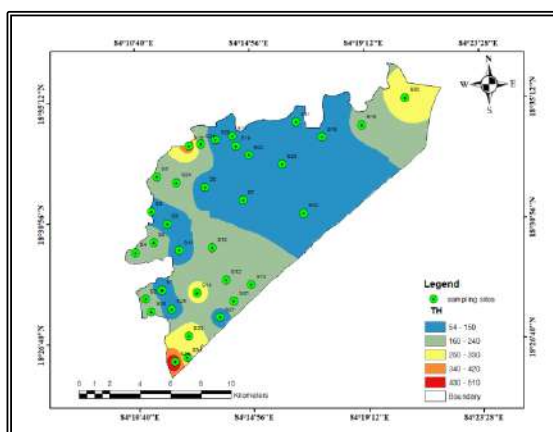


Figure 5(a): Total Hardness Pre monsoon **Figure 5(b): Total Hardness Post monsoon**

Calcium
Pre-monsoon calcium levels in the sampling locations range from 19 to 112 mg/l, and post-monsoon calcium levels range from 8 to 144 mg/l. It exceeds the 75 mg/l threshold in some of the stations. The greater value is primarily attributable to the region's plentiful limestone supply. As a result, calcium ions are more solubilized. These may be found in the Govindapuram, Jonnalapadu, Kakarapalli, kaseepuram, and Brundavanam areas and are safe for drinking if they are below 75 and unsuitable if they are between 75 and 200 and beyond 200. The regional distribution of the water quality metric calcium in both the pre- and post-monsoon is depicted in Figures 6(a) and 6(b).

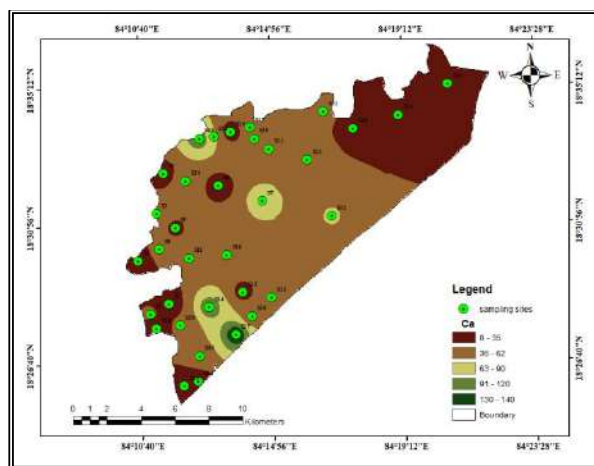
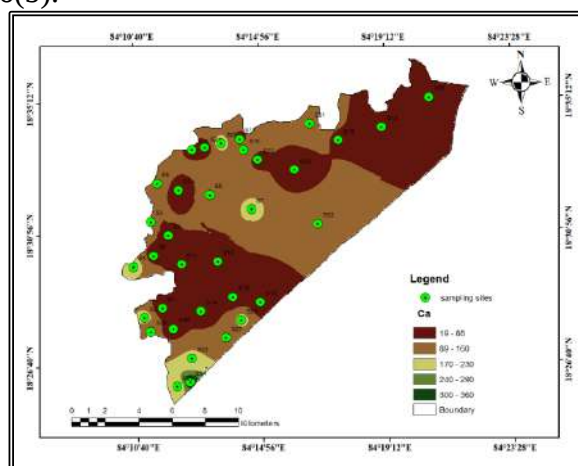


Figure 6(a): Calcium Pre monsoon **Figure 6(b): Calcium Post monsoon**

Magnesium

In the pre-monsoon and post-monsoon seasons, the sampling stations' magnesium concentrations range from -21 to 512 mg/l and 39 to 700 mg/l, respectively. Magnesium levels in several sampling points exceed the typical desired level in both seasons. Due to the dissolution of magnesium, calcite, gypsum, and dolomite, the concentration of magnesium may be very high. These are best suited for drinking values that are less than ideal (30 mg/l), acceptable (between 30 and 100 mg/l),

and unsuitable (more than 100 mg/l) that are found in the Borubhadra, Chinnathungam, Bavanapaadu, and Khaspanaupada area. The regional distribution of the water quality measure magnesium is depicted in Figures 7(a) and 7(b) for both pre- and post-monsoon conditions.

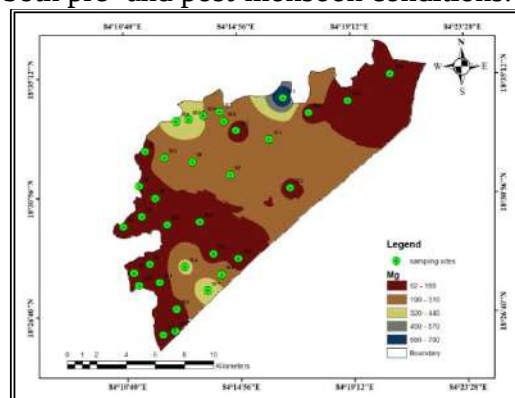
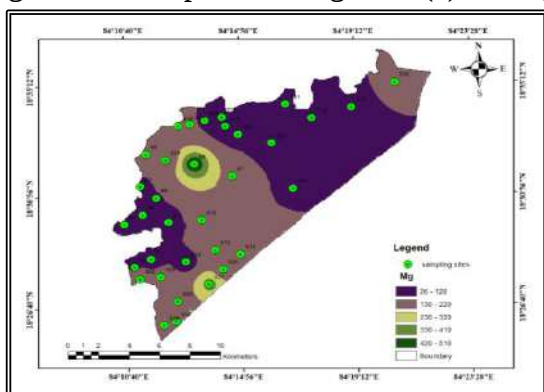


Figure 7(a): Magnesium Pre monsoon Figure 7(b): Magnesium Post monsoon

Sodium

Pre-monsoon sodium content in sampling sites ranged from 18.64 to 801 mg/l, whereas post-monsoon sodium concentration ranged from 6.9 to 215 mg/l. Fig.5.21a is a graph that compares sodium levels before and after the monsoon. In the Kollipaadu, Kotapaadu, Lakkvalasa, Palathalagam, and Malagam region, these are safe for drinking (20 mg/l) and not suitable for drinking (>200 mg/l). Figures 8(a) and 8(b) depict the regional distribution of the calcium water quality parameter before and after the monsoon.

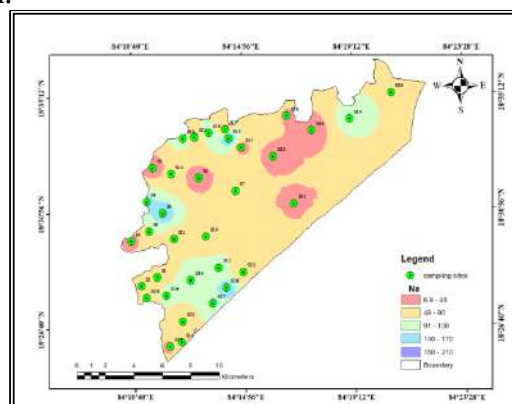
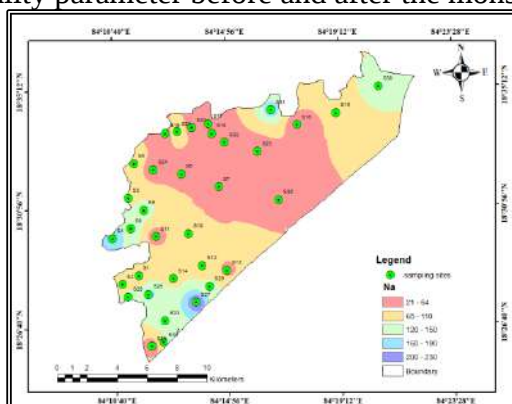


Figure 8(a) Sodium Pre monsoon Figure 8(b) Sodium Post monsoon

Potassium

Pre-monsoon sample locations had potassium concentrations ranging from 1.26 to 464 mg/l, whereas post-monsoon sites had concentrations ranging from 0.39 to 160 mg/l. In the Meghavaram, Bhavanapadu, Sandipeta, Seepuram, and Tallavalasa area, these are acceptable (>500 mg/l), not acceptable (>200 mg/l), and appropriate for drinking (100 mg/l). The spatial distribution of the water quality metric potassium in both the pre- and post-monsoon is depicted in Figures 9(a) and 9(b).

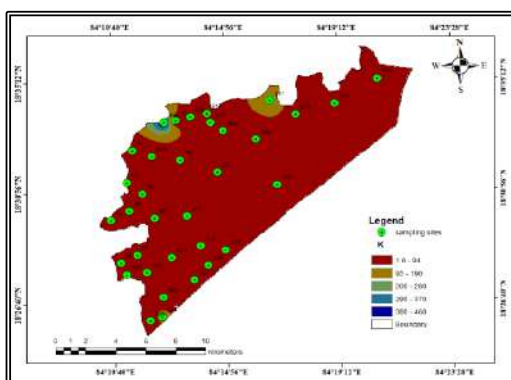


Figure 9(b): Potassium Post monsoon Bicarbonates

Pre-monsoon bicarbonate concentration in sampling sites ranged from 0.028 to 300 mg/l, and post-monsoon bicarbonate concentration ranged from 0.028 to 300 mg/l. The spatial distribution of the water quality measure bicarbonates in both the pre- and post-monsoon is depicted in Figures 10(a) and 10(b). The majority of the stations are substantially below the 45 mg/l acceptable limit. These are most suited for drinking when the value is below 45 mg/l and inappropriate when the value is above 45 mg/l and is found in the Santhabommali, Pothunaidupeta, Siddibherapuram, and Uddannapalem regions.

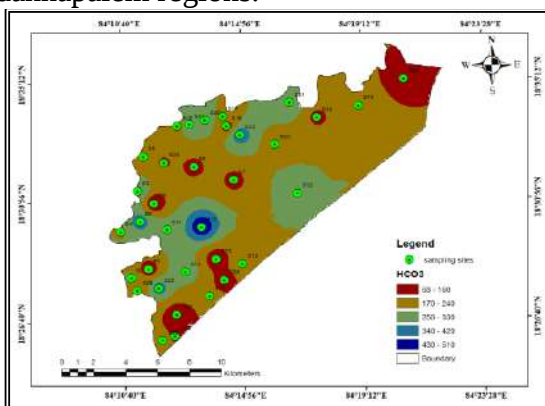


Figure 10(a): Bicarbonate Pre monsoon Nitrates

During the pre-monsoon season, nitrate content in the research sites ranged from 1.64 to 132.56 mg/l, while during the post-monsoon season, it ranged from 0.03 to 51 mg/l. The majority of the stations are substantially below the 45 mg/l acceptable limit. For newborns, Mathemoglobinemia, a severe condition, is brought on by nitrate concentrations of more than 45 mg/l. These are most suited for drinking levels below 45 mg/l, and they are unsuitable for drinking when levels above 45 mg/l are seen in the Santabommali, Antlavaram, Kakarapalli, Vaddithandra, and Kotapadu regions. The spatial distribution of the water quality metric nitrates in both premonsoon and postmonsoon conditions is depicted in Figures 11(a) and 11(b).

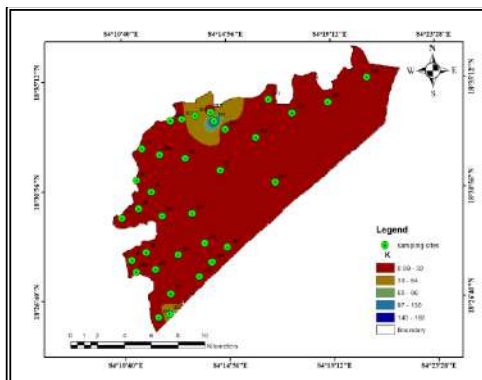


Figure 9(a): Potassium Pre monsoon

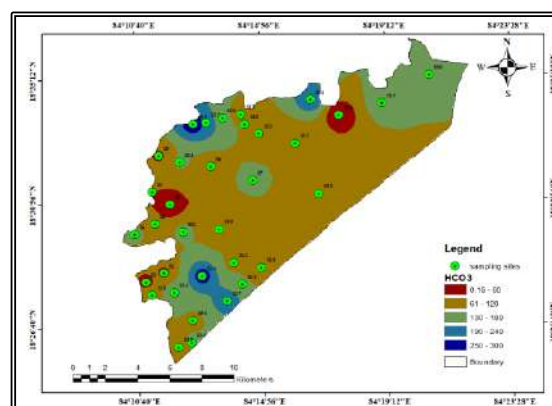


Figure 10(b): Bicarbonate Post monsoon

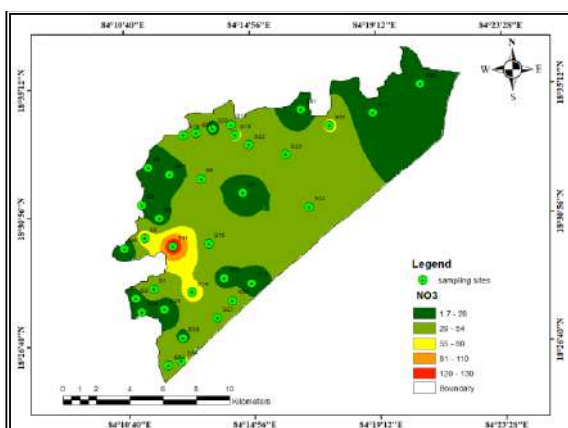


Figure 11(a): Nitrates Pre monsoon

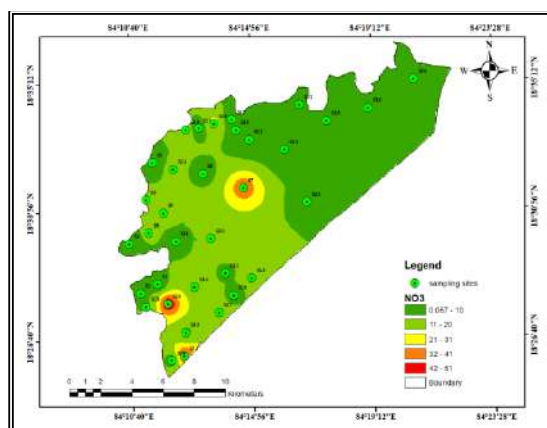


Figure 11(b): Nitrates Post monsoon

Chlorides

It was noted that the value of chlorides ranged from 29.98 to 499.48 mg/l during the pre-monsoon and from 30 to 499 mg/l during the post-monsoon. The most ideal level (250 mg/l) set by BIS was not met by the majority of the samples, however these values are still substantially below the maximum allowable limit (1000 mg/l). Anthropogenic activities such as the discharge from septic tanks and the use of bleaching products by local residents are to blame for the excess chloride. In the Naupaada, Meghavaram, Ummilada, Seepuram, and Mulapeta region, these are most acceptable for drinking (250 mg/l), and not suitable for drinking (between 250-600 mg/l and greater than 600 mg/l). The spatial distribution of the water quality measure chlorides in both the pre- and post-monsoon is depicted in Figures 12(a) and 12(b).

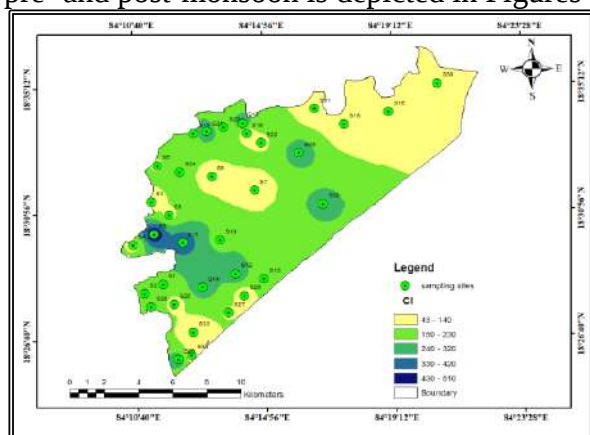


Figure 12(a): Chloride Pre monsoon

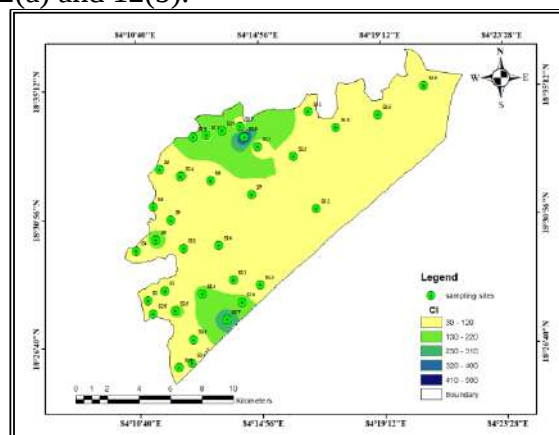


Figure 12(b): Chloride Post monsoon

Fluorides

Fluoride, the most prevalent form of fluorine, is a naturally occurring water pollutant. Fluoride is frequently dissolved by geological formation in groundwater. Pre-monsoon fluoride concentrations in the sampling locations range from 0.11 mg/l to 0.56 mg/l, whereas post-monsoon fluoride concentrations range from 0.1 to 1.3 mg/l. Fluoride levels that are too high can cause conditions like dental fluorosis and skeletal fluorosis. The Marripaadu, Maruvada, Peddathungam,

and Brundavanam area is where these are most suited for less than ideal drinking values (1 mg/l) and not suitable values for drinking (between 1-1.5 mg/l and greater than 1.5 mg/l). Fluorides, a water quality measure, are distributed spatially in Figures 13(a) and 13(b) for both pre- and post-monsoon conditions.

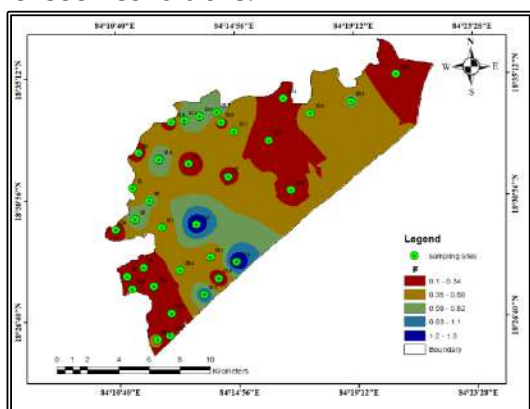


Figure 13(a): Fluoride Pre monsoon

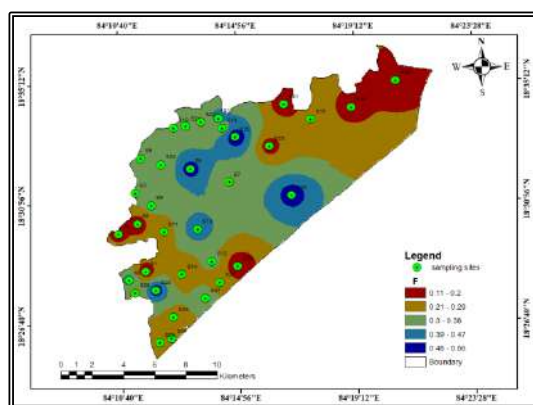


Figure 13(b): Fluoride Post monsoon

Sulphates
Pre-monsoon sulphate concentrations in the sampling sites ranged from 9 to 212 mg/l, whereas post-monsoon sulphate concentrations ranged from 0.82 to 374 mg/l. These are present in the Tallavalasa, Vaddithandra, Sandipeta, Seepuram, Palathalagam, and Kollipadu area and are safe for drinking (250 mg/l). The regional distribution of the water quality metric calcium in both the pre- and post-monsoon is depicted in Figures 14(a) and 14(b).

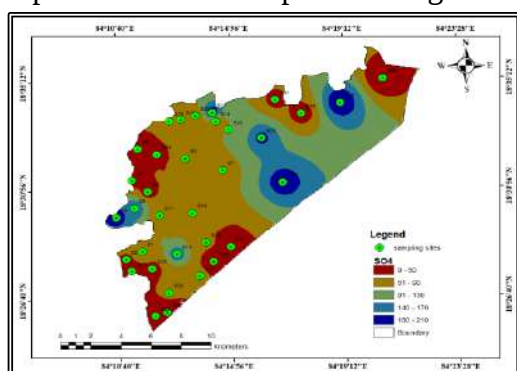


Figure 14(a): Sulphates Pre monsoon

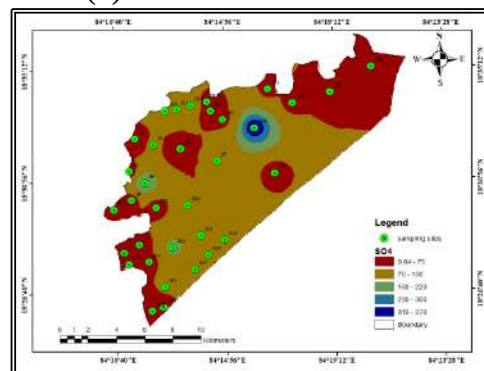


Figure 14(b): Sulphates Post monsoon

4. Conclusions

According to the current study's analysis of pre- and post-storm data as well as the normal qualities found, specific boundaries like calcium, magnesium, total hardness, and TDS have increased while other boundaries like pH, chlorides, fluorides, and nitrates have shrunk in significance. The rationale can be attributed to an increase in focus due to more significant filtering and a decrease in focus due to weakening [12]. Because of the rise in water usage and the scarcity of surface water during population growth and rapid industrialisation, the use of groundwater has gradually

increased [13]. The inquiry region's spatial depiction of groundwater quality now has its final result. The experiment demonstrates that some level of treatment is required before drinking the groundwater in the study area [14]. The investigation aids in both developing appropriate management practises to safeguard the groundwater sources as well as understanding the nature of water [15]. Water quality in wells near the cities of Bhavanapadu, Madyapeta, and Umilada have been negatively impacted by agricultural activity and the open-air disposal of industrial waste. The current investigation has not found any fluoride-contaminated water. Ten of the 34 groundwater stations in the studied area have nitrate fixation levels above 45 mg/l, which may result in blue infant illness in infants. The choice of a water supply source can then be made. Pre-rainstorm pH ranges from 6.5 to 8.8, and post-storm pH ranges from 7.2 to 8.9. Pre-storm EC was observed at 246 to 3301 s/min, and post-storm EC was observed at 330 to 2025 s/min. The regions of Kollipadu, Marripadu, Kuramanadhapuram, Brundavanam, and Pothunaidupeta exhibit electrical conductivity.

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