GIS based approach for the assessment of water quality of the biodiversity heritage site of India- the Ameenpur lake, Hyderabad

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Abstract

Ameenpur Lake, the Biodiversity Heritage Site of India is the first urban lake to be given the status of a heritage site by the National Biodiversity Authority of India in the year 2016. In the present study, the water quality of Ameenpur Lake has been carried out using GIS technology. The water samples were collected during Pre-Monsoon, Monsoon and Post-Monsoon seasons of the year 2019-20 and analysed for various physico-chemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Turbidity, Total Hardness, Total Alkalinity, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphates, Carbonates, Bicarbonates, Fluorides, Phosphates, Nitrates, Dissolved Oxygen, Chemical Oxygen Demand and Biological Oxygen Demand in the laboratory using American Public Health Association[1] standard methods for water and wastewater treatment. Obtained results were compared with Bureau of Indian Standards.[3]

The results indicate that lake water is slightly alkaline in nature and most of the parameters were exceeding the permissible limits in all the three seasons. Statistical analysis has been used to calculate the correlation coefficient of different parameters. The correlation matrix shows that total alkalinity has significant correlation with calcium and magnesium, EC with chlorides, nitrates and fluorides, total hardness with calcium, magnesium, bicarbonates and total alkalinity and bicarbonates with calcium.

Keywords: Ameenpur Lake, Biodiversity Heritage Site, GIS, Physico-Chemical Parameters, Correlation, Urban Lake.

Introduction

Water is one of the main ingredients for sustaining the life on earth. It is considered to be the most limiting factor for many aspects like environmental stability, biodiversity conservation, economic growth, health care and food security[2]. Due to its importance, the need to understand its quality and quantity has brought it the status of being monitored and managed. The quality of aquatic environment arises from physical, chemical and biological interactions[2]. Surface waters are most vulnerable to pollution due to their easy accessibility for disposal of wastewaters[7]. As for the lake water is concerned, it plays a significant role in various dynamic activities and hence constant assessment of water quality is needed.

Discharge of untreated sewage, industrial effluents and storm water runoff are few of the reasons for adding the nutrients[5] like phosphates, detergents and caustic soda etc. which are responsible for the huge amount of aquatic macrophytes. These effluents also have high levels of toxicity, colour, BOD, COD and at the same time it contains high level of heavy metals[9]. Though nutrient enrichment is beneficial for algal growth, it leads to deterioration of water quality and degradation of entire ecosystems[6].

It is a well-known fact that water quality deterioration is not due to any one specific reason. There exists strong correlations among different parameters and a combined effect of their inter-relatedness indicates the water quality[4].

The present study is aimed to determine the rate of degrading water quality and to give information about the parameters responsible for it. Spatial distribution zone maps of the surface water quality by using physico-chemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Turbidity, Total Hardness (TH), Total Alkalinity (TA), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), Sulphates (SO_4^{2-}), Carbonates (CO_3^{2-}), Bicarbonates (HCO_3^{-}), Fluorides (F^{-}), Phosphates (PO_4^{3-}), Nitrates (NO_3^{-}), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were made.

The geospatial tools like ArcGIS 10.8, IDW interpolation and GPS were used to generate the spatial distribution map of surface water for the Ameenpur Lake, Telangana. For the statistical analysis, Karl-Pearson correlation coefficient (r) was calculated and correlation of different physicochemical parameters was assessed.

Ameenpur Lake (17° 31.198'N, 78° 19.524'E) situated in Patancheru Mandal, Sangareddy District, Telangana State, India (Figure 1) covering an area of 93.15 acres[8] is the first urban lake to be declared as the Biodiversity Heritage Site in 2016 by the National Biodiversity Authority of India. Due to its rich biodiversity harbouring, the lake has received national recognition. But on the other side due to

urbanization and industrialization, the water quality of the lake on which this biodiversity depends, is under severe threat.

The lake is presently being polluted due to inflow of domestic sewage, industrial effluents, agricultural runoff and other activities such as disposing religious offerings during the festive seasons and from the three temples situated on the lake boundary, animal bathing and recreational activities. An unplanned and haphazard human settlement around the lake also poses a serious threat to this lake.

Material and Methods

The water samples were collected from 10 different locations (S1 to S10) (Figure 2) during Pre-monsoon (PRM), Monsoon (M) and Post Monsoon (POM) season in the year 2019-20 (Table 1). The physicochemical analysis was carried out for twenty parameters as per the APHA standard methods[1] for different parameters like pH (units), Conductivity (µS/cm), Total Dissolved Solid (mg/l), Nitrate (mg/l), Total Hardness (mg/l), Chloride (mg/l), Calcium (mg/l), Magnesium (mg/l), Sodium (mg/l), Potassium (mg/l), Phosphates, Fluorides (mg/l), Carbonates (mg/l), Bicarbonates (mg/l), Alkalinity (mg/l), Sulphate (mg/l), Dissolved Oxygen (mg/l), Biological Oxygen Demand (mg/l) and Chemical Oxygen Demand (mg/l) and the results were compared with BIS 2012 standards.[3]

Pearson's correlation coefficient (r) value was calculated for all the physico-chemical parameters used for the assessment of water quality of the study site. To calculate the correlation coefficients (r), correlation matrix was created using the coefficients of different pairs of parameters and further by applying the p-value, correlation for significance was tested. The variations are significant if $p<0.05$, $p<0.01$ and non-significant if $p>0.05$. The significance is considered at the level of 0.01 and 0.05 (2- tailed analysis). To identify the most significant parameter of water quality and its correlation with other parameters, correlation matrix studies were done. In this study, the correlation matrix of 20 variables was computed using SPSS software. The significance is considered at the level of 0.01 and 0.05 (2-tailed analysis)[7].

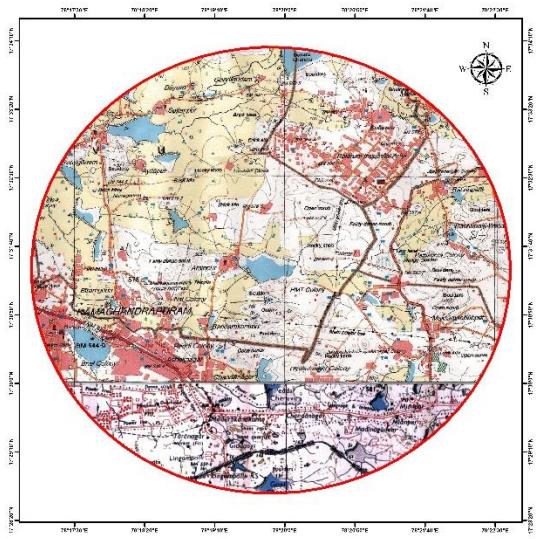

Figure 1: Mosaicked Toposheet No. 56k7 and E44M6 showing study area

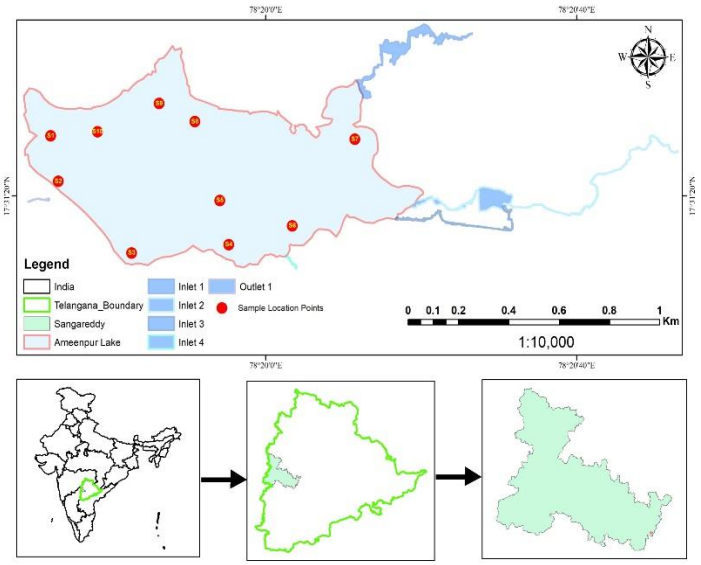

Figure 2: Study Area showing the sample location point

Table 1
Sampling locations points of Ameenpur Lake

S.N.	Sample ID	Location Name	Latitude	Longitude
1	S1	Sai Baba Temple	17.5243	78.3253
2	S2	Kattamaisamma Temple Steps	17.5225	78.3258
3	S3	Rock Area	17.52	78.3285
4	S4	Fisherman's Point	17.5203	78.3319
5	S5	Mid Lake	17.5218	78.3316
6	S6	Bird Watching Point	17.5211	78.3344
7	S7	Renuka Temple	17.5243	78.3368
8	S8	Opp. to Fisherman's Point	17.5247	78.3308
9	S9	Transformer Line	17.5253	78.3301
10	S10	Agricultural Field	17.525	78.3272

Results and Discussion

The obtained results of the physico-chemical parameters during pre-monsoon, monsoon and post-monsoon seasons are tabulated in table 2. The correlation matrix of twenty parameters namely pH, TDS, TH, TA, turbidity, carbonates, bicarbonates, sodium, calcium, potassium, magnesium, sodium, chlorides, sulphates, phosphates, nitrates, fluorides, DO, BOD and COD among themselves is shown in table 3.

pH: From the table 2, it is observed that the values ranged in between 7.4 to 8.53. The average pH values for Pre-Monsoon, Monsoon and Post-Monsoon season were 8.1, 7.7 and 7.9 respectively which are within the prescribed standards given by BIS. pH exhibited positive correlation with carbonates (r=0.76, p<0.01), sodium (r=0.304, p<0.05) and negative correlation with BOD (r= -0.358, p<0.05), TH (r= -0.425, p<0.01), bicarbonates (r= -0.534, p<0.01), total alkalinity (r= -0.446, p<0.01), calcium (r= -0.406, p<0.01) and magnesium (r= -0.416, p<0.01).

Electrical Conductivity (EC): In the present study the electrical conductivity was found to be ranging in between 1169 to 2800µS/cm. The average EC values for Pre-Monsoon, Monsoon and Post-Monsoon were 1938, 1462 and 1130 µS/cm respectively. EC of the sampling sites S1 and S5 of Pre-Monsoon and Monsoon exceeded the prescribed limit of BIS 2012.

Electrical conductivity exhibited positive correlation with turbidity (r= 0.704, p<0.01), total hardness (r= 0.519, p<0.01), total alkalinity (r= 0.378, p<0.05), calcium (r= 0.542, p<0.01), magnesium (r= 0.441, p<0.01), chlorides (r= 0.804, p<0.01), sodium (r= 0.751, p<0.01), sulphates (r= 0.578, p<0.01), nitrates (r= 0.839, p<0.01), fluorides (r= 0.853, p<0.01), COD (r= 0.427, p<0.01) and BOD (r=0.558, p<0.01) and exhibited negative correlation with TDS (r= -0.695, p<0.01).

Turbidity: The turbidity values ranged in between 6 to 220 NTU. The average values were 182.8, 21.59 and 21.1 NTU during the Pre-Monsoon, Monsoon and Post-Monsoon seasons respectively. The values of the samples exceed the prescribed limits of BIS 2012 i.e. 5 NTU. The turbidity exhibited positive correlation with chlorides (r=0.735, p<0.01), sodium (r=0.769, p<0.01), sulphates (r=0.648, p<0.01), nitrates (r=0.555, p<0.01), fluorides (r=0.546, p<0.01), BOD (r=0.661, p<0.01) and COD (r=0.360, p<0.05) and negative correlation with DO (r= -0.38, p<0.05). The spatial distribution maps of the pH, EC and Turbidity of all three seasons are shown in figure 3.

TDS: The TDS values of the samples ranged in between 711 to 1981 mg/l. The average concentrations of TDS present in water samples were in the range of 1308.5, 973.5 and 755.7 mg/l during the season of Pre-Monsoon, Monsoon and Post-Monsoon respectively. All the samples were having values exceeding the BIS limit of 200 mg/l. The high amount of TDS can be attributed to the untreated sewage discharges and different anthropogenic activities near the water body. TDS exhibited a positive correlation with DO (r=0.411, p<0.01) and negative correlation with turbidity (r= -0.871, p<0.01), carbonates (r= -0.433, p<0.01), chlorides (r= -0.660, p<0.01), sodium (r= -0.746, p<0.01), sulphates (r= -0.571, p<0.01), nitrates (r= -0.560, p<0.01), fluorides (r= -0.533, p<0.01), BOD (r= -0.611, p<0.01) and COD (r= -0.365, p<0.01).

Total Hardness: The total hardness of all the samples ranged in between 210 to 480 mg/l. The average concentration of hardness was found to be in the range of 258.6, 273 and 343 mg/l during Pre-Monsoon, Monsoon and Post-Monsoon season respectively. All the samples were having values exceeding the BIS limit of 200 mg/l. Total hardness exhibited positive correlation with bicarbonates (r=0.863, p<0.01), total alkalinity (r=0.886, p<0.01), calcium (r=0.971, p<0.01), magnesium (r=0.956, p<0.01), chloride (r=0.336, p<0.05), potassium (r=0.465, p<0.01), nitrates (r=0.746, p<0.01), fluorides (r=0.621, p<0.01) and BOD (r=0.503, p<0.01).

Total Alkalinity: In the present study, the total alkalinity values ranged in between 60-450 mg/l and the average values found during Pre-Monsoon, Monsoon and Post-Monsoon season were 146, 174 and 245.8 mg/l respectively. The alkalinity has values exceeding prescribed limit at the sampling sites S6 and S6 of Pre-Monsoon and Monsoon season respectively. All Post-Monsoon samples are exceeding the permissible limits given by the BIS standards of 200 mg/l. Total alkalinity exhibited positive correlation with calcium (r=0.899, p<0.01), magnesium (r=0.804, p<0.01), potassium (r=0.484, p<0.01), nitrates (r=0.587, p<0.01), fluorides (r=0.484, p<0.01), BOD (r=0.459, p<0.01) and phosphates (r=0.366, p<0.05). The spatial distribution maps of TDS, total alkalinity and total hardness of all three seasons are shown in figure 4.

Magnesium: The magnesium values ranged in between 22 to 52.8 mg/l. The mean values of magnesium were 30.3 mg/l, 36 mg/l and 25.5 mg/l during the Monsoon, Post-Monsoon and Pre-Monsoon respectively. According to the BIS standards, the desirable limit is 30 mg/l and samples S7 of Pre-Monsoon, S3 and S7 of monsoon and all samples of Post-Monsoon were exceeding the BIS standards. Magnesium exhibited positive correlation with potassium (r=0.433, p<0.01), nitrates (r=0.641, p<0.01), fluorides (r=0.567, p<0.01) and BOD (r=0.454, p<0.01).

Carbonates and Bicarbonates: In most of the samples, the carbonates were not found except in samples S1, S2, S3, S10 of Pre-Monsoon season having values 20, 30, 30 and 40 respectively. S1, S2 of Post-Monsoon were 12 and 12 respectively and S5 of monsoon was 30. The values ranged in between 12-40 mg/l.

In all the samples of all the seasons, the bicarbonates were found to be present and the values ranged in between 30 to

450. Carbonates exhibited positive correlation with sodium (r=0.336, p<0.05). Bicarbonates exhibited positive correlation with total alkalinity (r=0.961, p<0.01), calcium (r=0.871, p<0.01), magnesium (r=0.793, p<0.01), potassium (r=0.659, p<0.01), nitrates (r=0.478, p<0.01), sulphates (r=0.366, p<0.05) and fluorides (r=0.311, p<0.05) and BOD (r=0.435, p<0.01) and negative correlation with sodium (r= -0.350, p<0.05). The spatial distribution maps of magnesium and bicarbonates of all three seasons are shown in figure 5.

Sodium: The sodium values ranged in between 102 to 330 mg/l. The average values of sodium were 312.4, 207.5 and 119.7 mg/l for the Pre-Monsoon, Monsoon and Post-Monsoon respectively. All the samples of the Pre-Monsoon season are exceeding the prescribed limit of BIS 2012 whereas samples S2, S4, S5, S6, S8 and S10 of monsoon season also exceed the prescribed limits.

All the samples of the Post-Monsoon season were within the prescribed limits. Sodium exhibited positive correlation with sulphates (r=0.838, p<0.01), nitrates (r=0.533, p<0.01), fluorides (r=0.625, p<0.01), COD (r=0.381, p<0.05) and BOD (r=0.312, p<0.05) and negative correlation with potassium (r= -0.540, p<0.05).

Calcium: The calcium values ranged in between 44-145 mg/l. The average concentration of calcium of the different samples in study region during Pre-Monsoon, monsoon and Post-Monsoon seasons was found to be 61.2, 58.3 and 78 mg/l. All the values of calcium in sites S1 to S10 were observed below the desirable limit to BIS of 75 mg/l except the samples S3, S4, S6, S7, S8 and S9 of Post-Monsoon season and S7 of both Pre-Monsoon and monsoon season. The calcium is present naturally in the earth crust or can be due to the presences of limestone deposits. Calcium exhibited positive correlation with magnesium (r=0.858, p<0.01), chlorides (r=0.340, p<0.05), potassium (r=0.476, p<0.01), nitrates (r=0.778, p<0.01), fluorides (r=0.615, p<0.01) and BOD (r=0.512, p<0.01).

Potassium: The potassium values ranged in between 2.1 to 17.2 mg/l. The average values of potassium were 5.5, 28.6 and 157 mg/l for the Pre-Monsoon, Monsoon and Post-Monsoon respectively. All the samples of the Post-Monsoon season were exceeding the prescribed limits and all the other samples of Pre-Monsoon and monsoon were within the limits of 10mg/l. Potassium exhibited negative correlation only with sulphates (r= -0.574, p<0.01). The spatial distribution maps of sodium, calcium and potassium of all three seasons are shown in figure 6.

Fluorides: The values ranged in between 0.68 to 1.3 ppm. The mean values of fluorides present in study during monsoon was 0.89 mg/l, Post-Monsoon was 0.76 mg/l and Pre-Monsoon was 0.96 mg/l. All the values of fluorides from sampling sites except S6 of Pre-Monsoon and monsoon season were well within the desirable limit i.e. 1 mg/l as prescribed by BIS 2012. Fluorides exhibited positive correlation with COD (r= 0.477, p<0.01) and BOD (r= 0.418, p<0.01).

Nitrate: The values ranged between 12.6 to 29 mg/l. The mean concentration of NO3 in all water samples in study region during Monsoon was 16.1 mg/l, Post-Monsoon was 17.1 mg/l and Pre-Monsoon was 19.9 mg/l. All the values were well within the permissible limits of BIS 2012. Nitrates exhibited positive correlation with fluorides (r= -0.835, p<0.01), COD (r= -0.423, p<0.01) and BOD (r= -0.422, p<0.01).

Chlorides: The values ranged in between 180 to 550 mg/l. The average concentrations of chlorides in all the samples were observed to be 431.5, 274 and 257 mg/l during Pre-Monsoon, Monsoon and Post-Monsoon season respectively. All the values of chlorides concentration were exceeding the permissible limits of BIS 2012 of 250 mg/l.

The sources may be due to the leaching from various rocks, surface run-off from inorganic fertilizers and faecal matter containing high quantity of chlorides along with nitrogenous wastes. Chlorides exhibited positive correlation sodium (r=0.807, p<0.01), sulphates (r=0.525, p<0.01), nitrates (r=0.811, p<0.01), fluorides (r=0.716, p<0.01) and BOD (r=0.351, p<0.05). The spatial distribution maps of fluorides, nitrates and chlorides of all three seasons are shown in figure 7.

Sulphates: The values ranged in between 55 to 199 mg/l. The average concentrations during the Pre-Monsoon, Monsoon and Post-Monsoon seasons were 174.3, 139.5 and 80.39 mg/l respectively. All the values were well within the permissible limits of BIS 2012 of 200mg/l. Sulphates exhibited positive correlation with fluorides (r=0.523, p<0.01), nitrates (r=0.354, p<0.05), COD (r=0.385, p<0.05) and BOD (r=0.306, p<0.05).

Phosphates: Phosphates values ranged in between 0.7 to 18.9 mg/l. The average concentrations during the Pre-Monsoon, monsoon and Post-Monsoon seasons were 1.6, 5.1 and 1.7 mg/l respectively. Phosphates exhibited no correlation with any other physic-chemical parameter. The spatial distribution maps of sulphates and phosphates of all three seasons are shown in figure 8.

Dissolved Oxygen: In the present study, dissolved oxygen was found in the range of 2.3 mg/l to 3.1 mg/l with an average of 2.81 mg/l, this can be attributed to the addition of oxidisable organic matter from the effluents, biodegradation and decay of vegetation at higher temperature thereby taking oxygen from water.

DO concentrations below 2mg/l may cause fish mortality and below 5 mg/l may affect the functions and survival of biological communities. Water with inadequate DO may be considered as a wastewater. The DO values obtained in the present study are less compared to ICMR standards i.e. >5

mg/l. DO exhibited negative correlation with COD (r= -0.643, p<0.01) and BOD (r= -0.479, p<0.01).

Biological Oxygen Demand: In the present study, the biochemical oxygen demand (BOD) was found in the range of 70 mg/l to 135 mg/l with an average of 94.55 mg/l. The high levels of BOD can indicate the nature of chemical pollution. The BOD values obtained in the present study exceed the ICMR standards i.e. 5.0mg/l.

Chemical Oxygen Demand: In the present study, chemical oxygen demand (COD) value was found in the range of 210 mg/l to 380 mg/l with an average of 272.73 mg/l. The Spatial Distribution Maps of DO, BOD and COD of all three seasons are shown in figure 9.

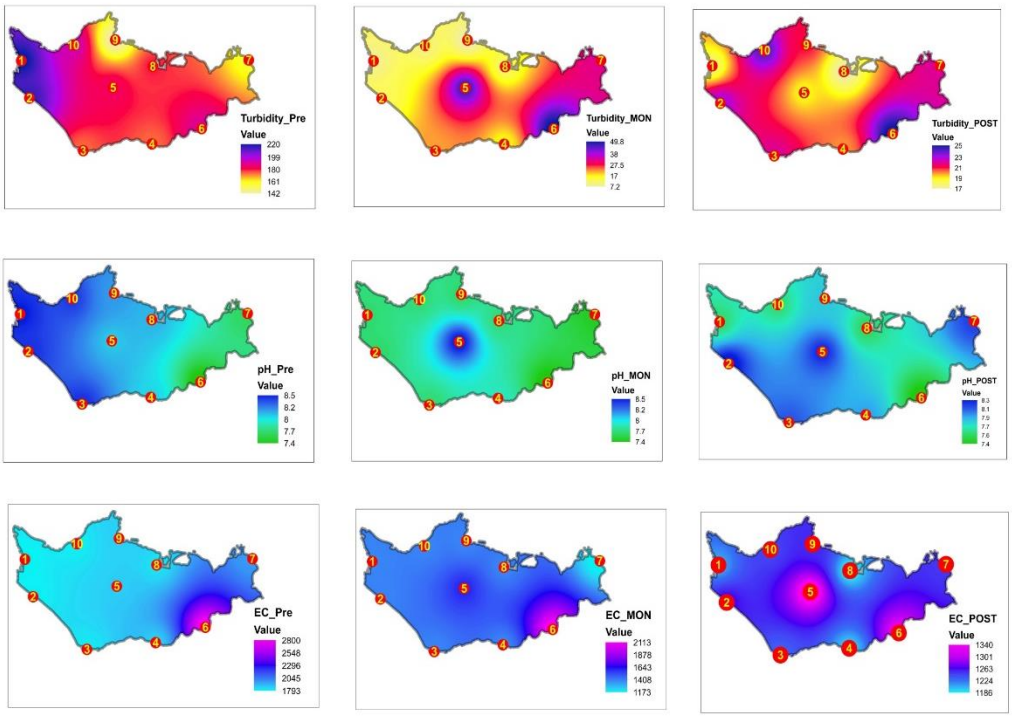

Figure 3: Spatial Distribution Maps of Turbidity, pH and EC of all three seasons.

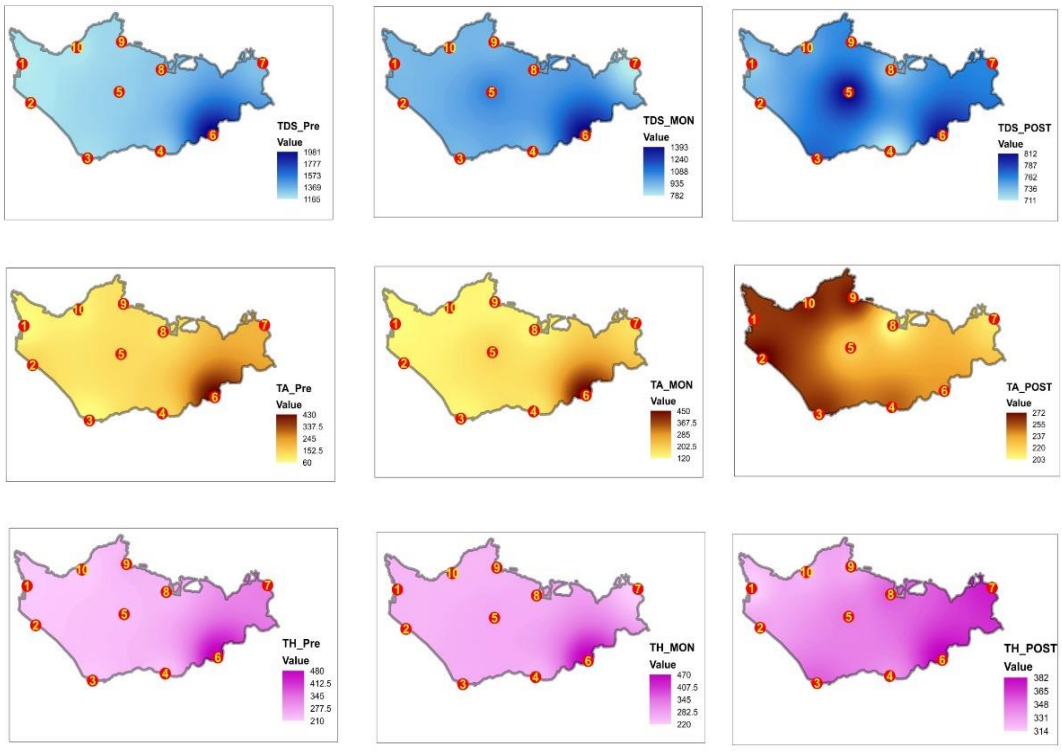

Figure 4: Spatial Distribution Maps of TDS, TA and TH of all three seasons

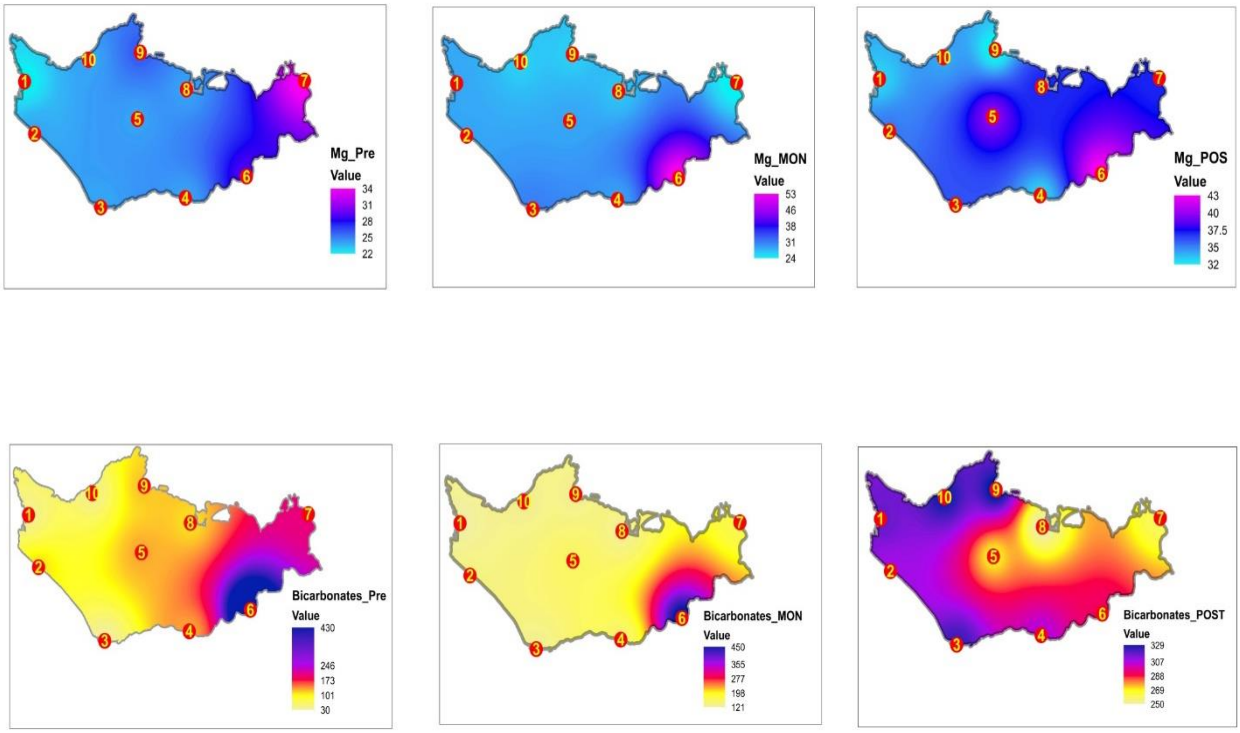

Figure 5: Spatial Distribution Maps of Magnesium and bicarbonates of all three seasons.

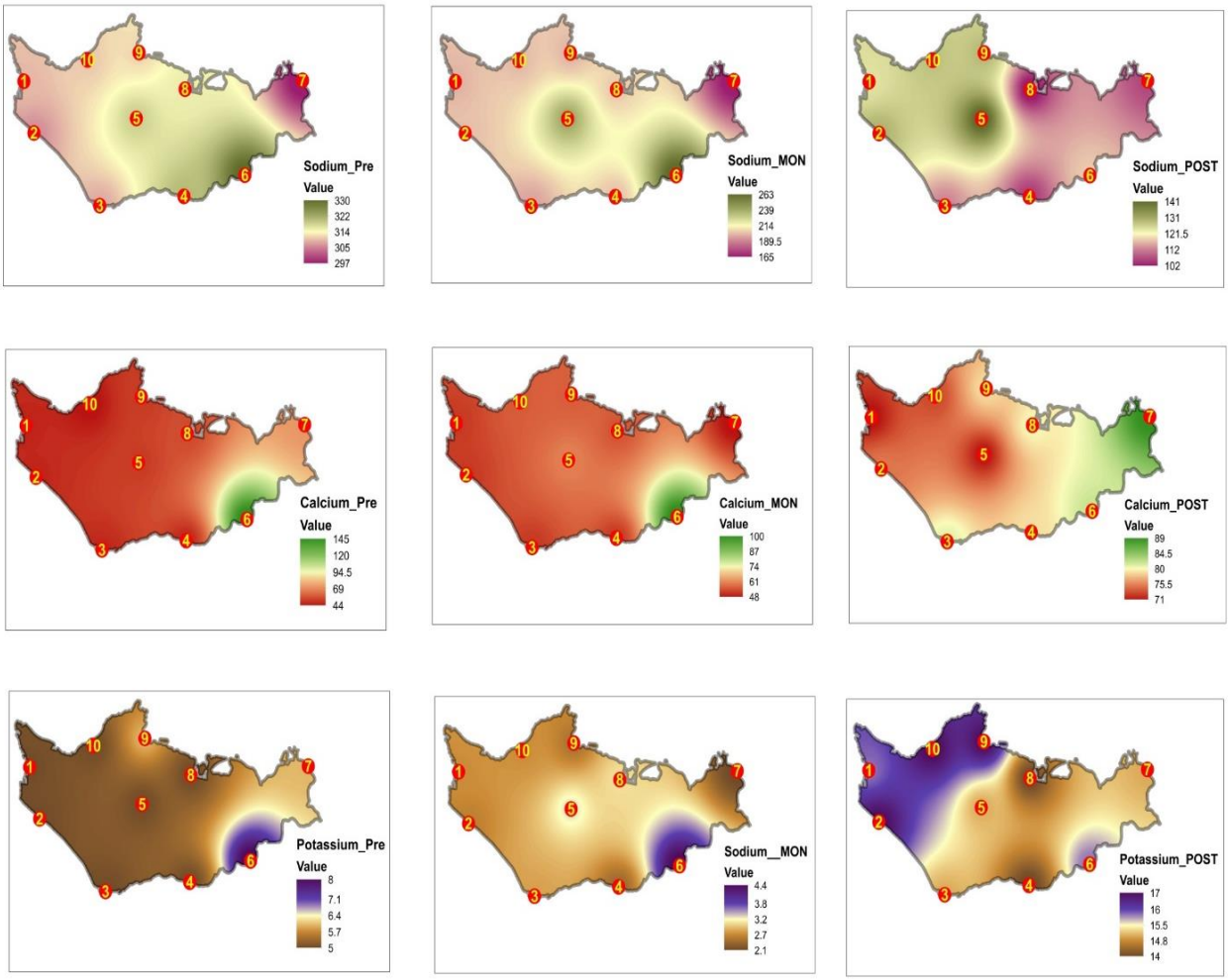

Figure 6: Spatial Distribution Maps of Sodium, Calcium and Potassium of all three seasons

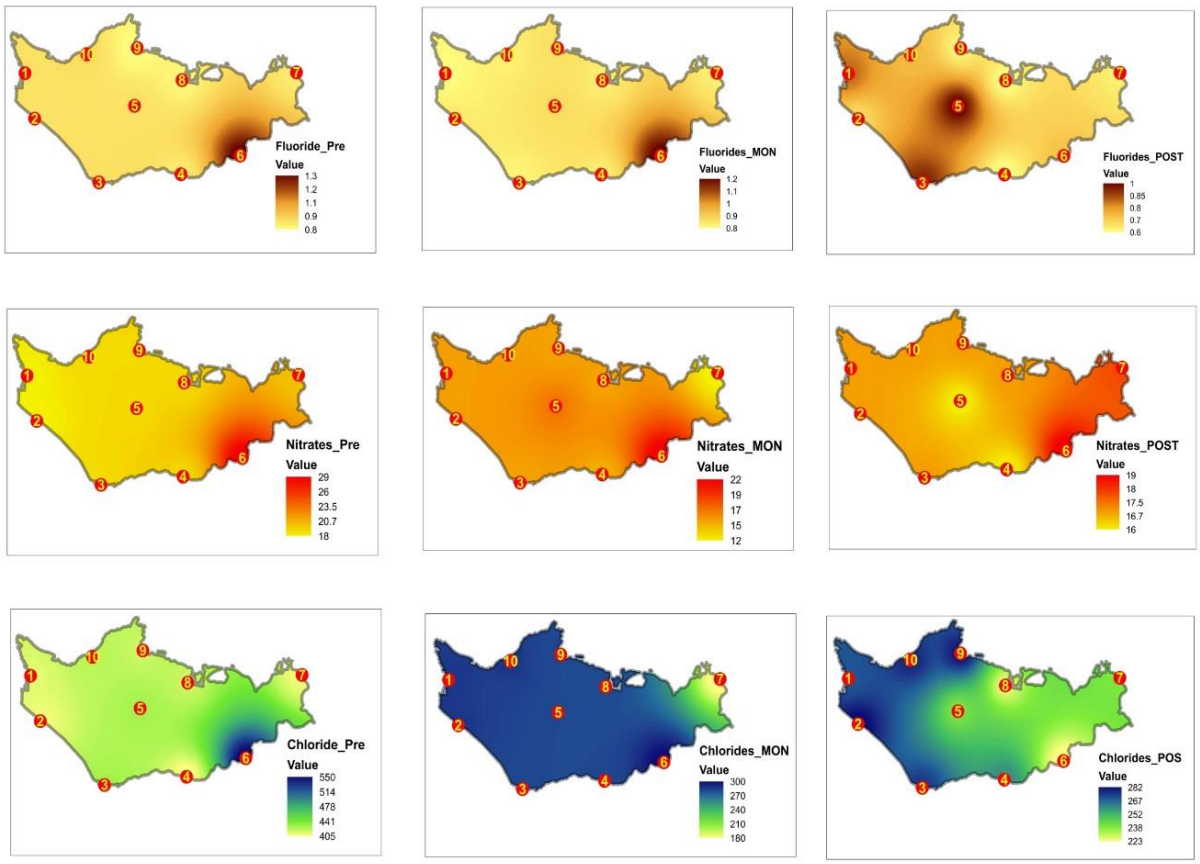

Figure 7: Spatial Distribution Maps of Fluorides, Nitrates and Chlorides of all three seasons.

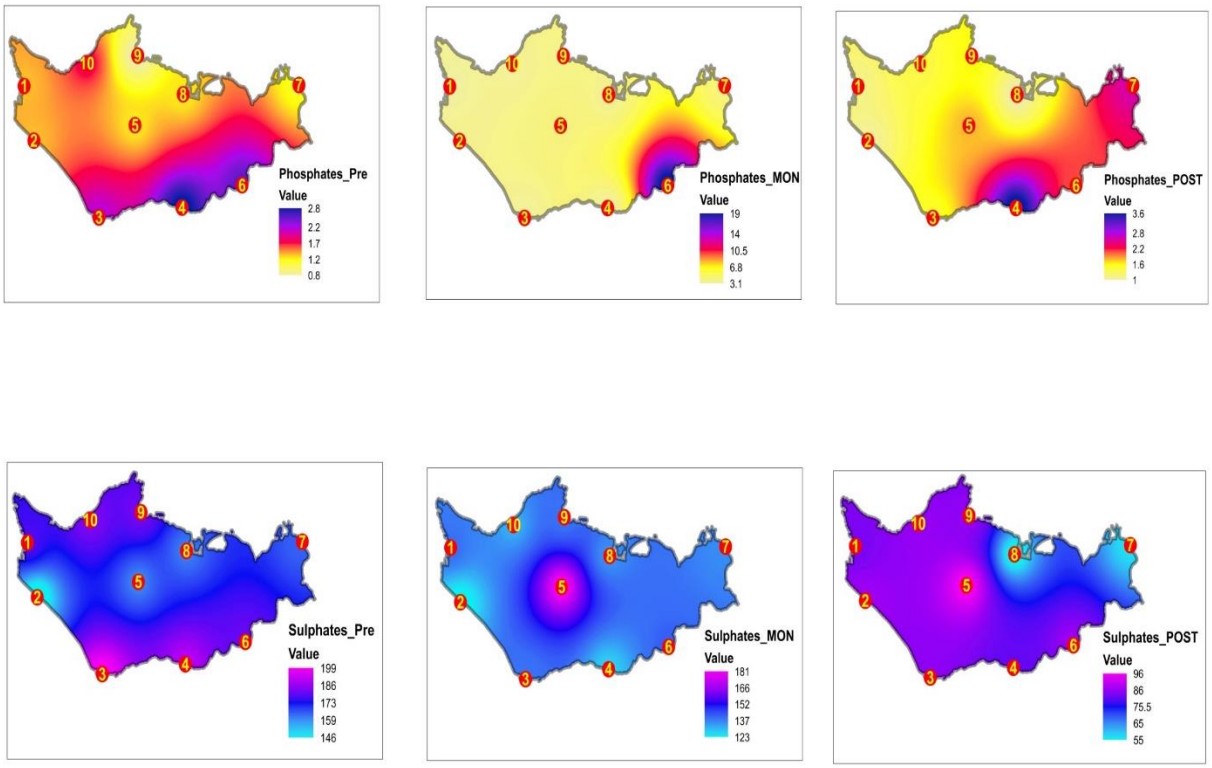

Figure 8: Spatial Distribution Maps of Phosphates and Sulphates of all three seasons.

Table 2
Chemical Analysis of water samples for Pre-Monsoon, Monsoon and Post-Monsoon season (All parameters are in mg/l except pH &EC (µS/cm)

S.N.	Season	pH	EC	TDS	Turbidity	TH	CO_3^{2-}	HCO_3^-	TA	Ca^{2+}	Mg^{2+}	Cl^-	Na^+	K^+	SO_4^{2-}	NO_3^-	F^-	PO_4^{3-}	COD	BOD	DO
BIS 2012 Standard		**6.5-8.5**	**1500**	**2000**	**5**	**200**	**-**	**-**	**200**	**75**	**30**	**250**	**200**	**10**	**200**	**45**	**1**	**-**	**-**	**<2**	**>5**
S1	PRM	8.53	1793	1165	220	210	20	40	60	48	22	415	309	5	178	18	0.95	1.4	260	90	2.7
	M	7.68	1388	912	9	250	Nil	120	120	52	29	285	200	2.7	140	16	0.82	3.2	100	32	4.5
	POM	7.61	1207	728	18	314	12	316	259	71	33	269	124	16	83	17	0.83	1.1	132	23	7.5
S2	PRM	8.47	1799	1182	215	220	30	110	140	48	24	410	306	5	146	18	0.94	1.4	220	80	3.1
	M	7.66	1395	922	13	250	Nil	140	140	52	29	285	202	2.6	123	16	0.86	3.7	150	50	4
	POM	8.31	1267	736	23	329	12	308	272	75	35	282	130	17	87	17	0.72	1.0	86	49	4.7
S3	PRM	8.48	1809	1208	174	220	30	30	60	48	24	430	308	5	199	19	0.95	2.2	230	80	3
	M	7.68	1393	925	22	260	Nil	130	130	52	31	280	196	2.8	139	16	0.84	3.4	120	39	4.4
	POM	8.14	1231	773	22	353	Nil	322	264	81	36	274	112	15.1	85	17	0.88	1.5	70	35	6.5
S4	PRM	8.03	1859	1258	174	220	Nil	130	130	48	24	405	320	5	190	19	0.92	2.8	310	110	2.7
	M	7.87	1388	915	17	250	Nil	150	150	52	29	280	203	2.4	128	15	0.85	3.2	120	39	4.3
	POM	7.98	11.69	711	20	335	Nil	306	251	79	33	260	106	14.4	81	16	0.68	3.6	101	28	3.8
S5	PRM	8.05	1868	1265	184	230	Nil	130	130	52	24	430	318	5	160	19	0.95	1.3	280	100	2.9
	M	8.53	1605	1063	47	270	30	160	190	60	29	280	240	3.3	181	17	0.89	4.2	150	45	3.5
	POM	8.24	1340	812	19	343	Nil	269	221	71	40	238.6	141	15.2	96	16	0.91	1.8	156	42	5.5
S6	PRM	7.4	2800	1981	191	480	Nil	430	430	145	29	550	330	8	180	29	1.3	2.5	360	130	2.5
	M	7.43	2113	1393	50	470	Nil	450	450	100	53	300	263	4.4	142	22	1.2	18.9	360	120	1.9

	POM	7.41	1320	805	25	382	Nil	292	239	82	43	223	118	16	87	19	0.75	2.05	614	60	0.6
S7	PRM	7.63	1965	1310	158	320	Nil	200	200	72	34	410	297	6	164	20	0.92	1.2	220	75	3.1
	M	7.5	1173	782	33	220	Nil	170	170	48	24	180	165	2.1	136	13	0.85	4.2	290	96	1.3
	POM	8.18	1249	760	22	372	Nil	260	213	89	37	239	107	15	58	18	0.7	2.6	114	45	5.1
S8	PRM	8.1	1820	1288	180	236	Nil	110	110	55	24	420	315	5	161	19	0.9	1.3	275	90	2.8
	M	7.7	1390	984	12	260	Nil	130	130	55	27	280	205	3.1	135	16	0.85	3.5	120	35	4.2
	POM	7.59	1186	728	17	353	Nil	247	203	80	37	227	102	14	55	17	0.68	0.9	57	49	0.9
S9	PRM	8.18	1866	1242	138	240	Nil	120	120	52	26	420	311	6	182	19	0.88	0.7	210	70	3
	M	7.66	1390	919	6	250	Nil	130	130	56	26	280	200	2.5	139	16	0.88	3.9	130	40	4.2
	POM	7.88	1255	759	21	326.14	Nil	329	269	79	32	280	129	17	86	17	0.69	1.6	60	24	4.1
S10	PRM	8.45	1801	1186	194	210	40	40	80	44	24	425	310	5	183	19	0.96	1.8	240	80	3
	M	7.69	1392	920	10	250	Nil	130	130	56	26	285	201	2.7	132	16	0.85	3.5	120	39	4.3
	POM	7.63	1243	745	24	323	Nil	326	267	73	34	277	128	17	86	17	0.76	1.4	135	25	7.2

Table 3
Correlation coefficients values among the various water quality parameters

	pH	EC	TDS	Turbidity	TH	CO_3^{2-}	HCO_3^-	TA	Ca^{2+}	Mg^{2+}	Cl^-	Na^+	K^+	SO_4^{2-}	NO_3^-	F^-	PO_4^{3-}	COD	BOD	DO
pH	1																			
EC	-0.044	1																		
TDS	-0.282	-0.695**	1																	
Turbidity	0.166	0.704**	-0.871**	1																
Total Hardness	-0.425**	0.519**	-0.228	0.195	1															

DO	BOD	COD	Phosphates	Fluoride	Nitrates	Sulphates	Potassium	Sodium	Chloride	Magnesium	Calcium	Total alkalinity	Bicarbonates	Carbonates
0.189	-0.358*	-0.161	-0.212	-0.106	-0.100	0.133	-0.154	0.304*	0.196	-0.416**	-0.406**	-0.446**	-0.534**	0.763**
-0.283	0.558**	0.427**	0.086	0.853**	0.839**	0.578**	-0.157	0.751**	0.804**	0.441**	0.542**	0.378*	0.222	0.168
0.411**	-0.611**	-0.365*	-0.091	-0.533**	-0.560**	-0.571**	0.077	-0.746**	-0.660**	-0.159	-0.268	-0.220	-0.067	-0.433**
-0.380*	0.661**	0.360*	-0.186	0.546**	0.562**	0.648**	-0.082	0.770**	0.735**	0.109	0.249	0.080	-0.026	0.254
-0.116	0.503**	0.184	0.180	0.621**	0.746**	-0.131	0.465**	-0.049	0.336*	**0.956****	**0.971****	0.886**	0.863**	-0.153
-0.118	-0.110	0.088	0.041	0.142	0.065	0.193	-0.202	0.336*	0.187	-0.155	-0.145	-0.102	-0.287	1
-0.013	0.435**	0.085	0.269	0.311*	0.478**	0.365*	0.659**	-0.350*	0.021	0.793**	0.871**	**0.961****	1	
-0.111	0.459**	0.191	0.366*	0.484**	0.587**	-0.215	0.484**	-0.170	0.128	0.804**	**0.899****	1		
-0.113	0.512**	0.178	0.134	0.615**	0.778**	-0.121	0.476**	-0.014	0.390*	0.858**	1			
-0.107	0.454**	0.173	0.218	0.567**	0.641**	-0.145	0.433**	-0.101	0.237	1				
-0.107	0.351*	0.280	-0.166	0.716**	0.811**	0.525**	-0.098	0.807**	1					
-0.292	0.312*	0.381*	0.014	0.625**	0.533**	0.838**	-0.540**	1						
0.254	0.245	-0.245	-0.200	-0.242	0.113	-0.574**	1							
-0.302	0.306*	0.385*	0.004	0.523**	0.354*	1								
-0.185	0.422**	0.423**	0.027	0.835**	1									
-0.248	0.418**	0.477**	0.236	1										
-0.260	0.183	0.207	1											
-0.643**	0.272	1												
-0.479**	1													
1														

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

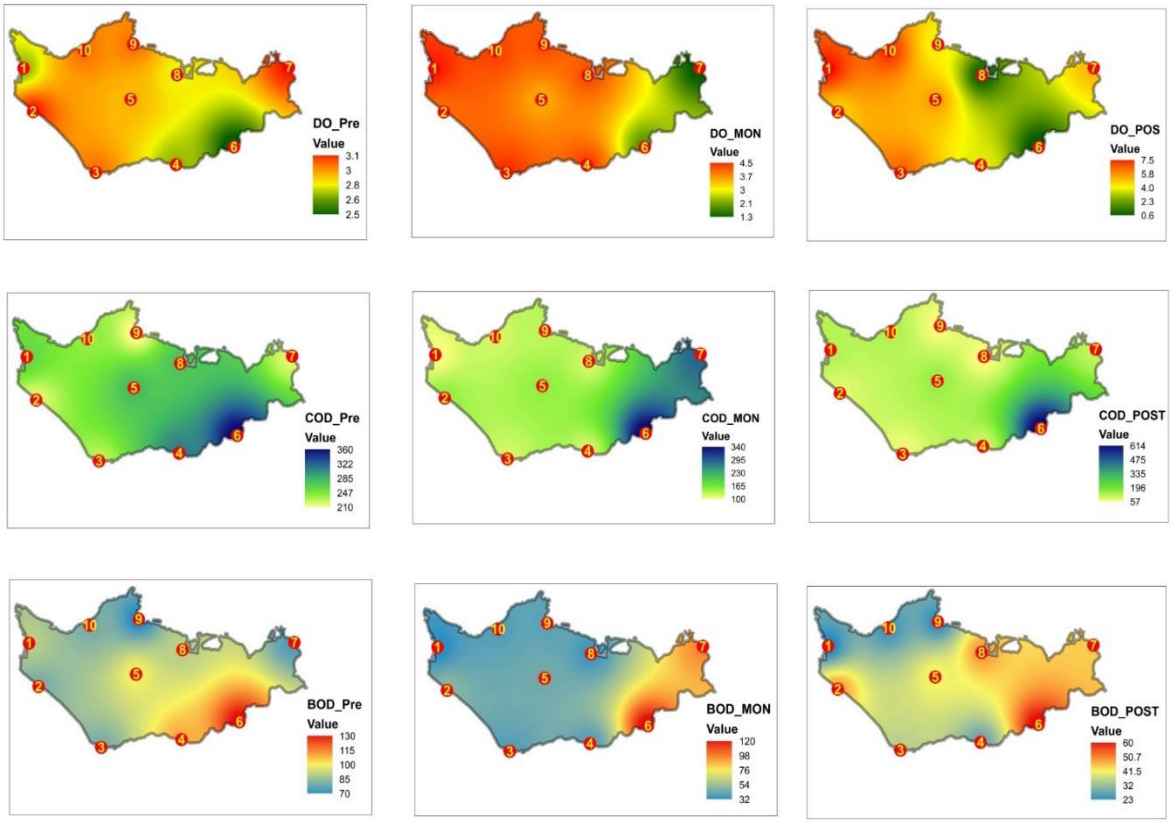

Figure 9: Spatial Distribution Maps of DO, BOD and COD of all three seasons

Conclusion

The present study was carried out at the ten sample sites of the Ameenpur Lake, Telangana to understand the spatial distribution of water quality parameters for all the three seasons. The results indicate that TDS, TH, Turbidity and BOD were exceeding the permissible limits in all the three seasons. The deteriorating quality of water may be due to the increase in human settlements and industrialization around the lake. A significant correlation is exhibited by total hardness with calcium (0.9) and magnesium (0.9).

Bicarbonates also exhibited strong correlation with total alkalinity (0.9) and total alkalinity with calcium (0.9). Thus, the Pearson's correlation has been found to be an important tool to get accurate evidence of the quality of the surface water by assessing the important parameters experimentally.

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