International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

ASSESSMENT OF SURFACE AND GROUNDWATER QUALITY OF ANEKAL TALUK USING ADVANCED TECHNIQUES

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Abstract - *In this study the suitability of groundwater quality for drinking and agricultural purposes was assessed in the rural areas of Anekal taluk based on the various water quality parameters. A total of 50 surface water and 10 groundwater samples were collected randomly from different sources and analyzed for major ion chemistry to understand the operating mechanism of geochemical processes for groundwater quality. The quality analysis is performed through the estimation of pH, EC, TDS, total hardness, total alkalinity, Cl, NO3, SO4, Cu, Ni, Zn and Pb etc.*

Key Words: WATER QUALITY ASSESSMENT, WQI, GIS CONTOURING, HEAVY METAL ANALYSIS.

1.INTRODUCTION

Water is an incredibly important and valuable resource that is crucial for all forms of life on Earth. While the planet has a vast amount of water, about 1.4 × 109 cubic kilometers, only a small portion, around 3%, is freshwater available in rivers, lakes, and underground sources. The availability of clean freshwater is limited, and the growing population and industrialization have led to a significant demand that surpasses the available supply. Access to clean water is a vital indicator of development in any country.

Groundwater resource in Anekal Taluk is widely exploited for irrigation and other domestic purposes in addition to drinking purpose. The taluk resident mainly depends on groundwater for their drinking water. Concentration of pollutants more than their permissible limits in drinking water leads to health problems, such as water borne diseases, like fluorosis, typhoid, jaundice, cholera, premature baby and other problems, especially in infants. Anekal Taluk is located in the southeast corner of Karnataka state spans to a geographical area of 2,191 km2. Anekal Taluk occupies an area about 535 km2 The topography of the region is uneven landscape with intermingling of hills and valleys and bare rocky outcrops raises to about 60 to 90 feet above ground level. The ground is dissected and is a region of rapid erosion. The eastern portion of taluk forms a plain country and western portion is wild and marked by a continuous chain of hills through which several rivulets combine together and drain into river Arkavathi. Geologically, gneissic granites and dyke rocks are found belonging to Precambrian age. Groundwater in the district occurs under water table conditions in the weathered mantle of granitic gneisses and joints, cracks and crevices of the basement rock. It is estimated that surface run off and evapotranspiration account for nearly 80% allowing only 20% of rainfall adding to groundwater reservoir.

2. STUDY AREA

Anekal taluk is our study area, located between 12º 39' 39" to 12º 56' 30" North latitude and 77º 31' to 77º 50' East latitude. It spans 512 square kilometers and has an uneven landscape with hills and valleys. The terrain is highly dissected, indicating rapid erosion. The eastern part is relatively flat, while the western part is densely hilly. The climate is moderate, without excessive humidity or dryness. As part of the KC valley project, 120 MLD of treated water is being pumped to four link lakes, which are connected to approximately 60 downstream tanks in Anekal. The Minor Irrigation Department is responsible for implementing the KC valley project. They have also initiated a 260-crore project to supply 120 MLD of treated water from KC valley to Anekal in Bengaluru Urban district and certain areas of Kanakapura in Ramanagara district.

3. OBJECTIVES

- To conduct field investigation to identify the Ground and Surface water contaminations.
- To suggest probable remediation methods to restore community health hazards related to portable water.
- Use of nanoparticles for removal of excess contamination.
- To assess the suitability of Ground and Surface water for agricultural and industrial purposes.

4. METHODOLOGY

SAMPLE COLLECTION

Grab sampling method is to be adopted to collect water samples. The samples were collected in polythene containers of 2 liters capacity for physiochemical analysis. The water samples to be collected from various locations of Anekal taluk. The collected water samples are to be stored in the cold storage while transportation. A total sample of 60 Surface water and 25 Groundwater are to be collected from the various places around the Anekal taluk.

EXPERIMENTAL METHODS

The collected water samples are tested in the laboratory for the water parameters like pH, EC, Chlorides, Hardness, Turbidity, Alkalinity, Acidity, Total dissolved solids, Calcium,

Magnesium, Sulfate, Nitrate, and Fluoride. These parameters are analysed in the laboratory of Dayananda sagar college of Engineering, Bangalore. The test are performed as per procedure set by the Bureau of Indian Standards.

WATER QUALITY INDEX

The Water Quality Index (WQI) is a numerical scale used to assess and communicate the overall quality of water based on multiple water quality parameters. It provides a simplified way to understand and compare the quality of different water sources. The specific parameters and their respective weights in the index may vary depending on the region or organization using it, but generally, the WQI considers the physical, chemical, and biological parameters of the water.

Table 1 WQI for potable water.

WQI	Water quality category
<25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unsuitable for drinking

Table 2 WQI for agricultural and industrial use.

WQI	For agriculture usage	
	Water quality category	Possible usage
0-50	Excellent	Drinking, irrigation and industrial
50-100	Good	Drinking, irrigation and industrial
100-200	Poor	Irrigation and industrial
200-300	Very Poor	Irrigation
Above 300	Unsuitable for drinking and fish culture	Proper treatment required before us

HEAVY METAL ANALYSIS

Heavy metal analysis is a crucial step in environmental monitoring, food safety, and industrial processes. One commonly used technique for the analysis of heavy metals is atomic absorption spectroscopy (AAS). AAS is a technique that measures the absorption of light by atoms in a sample. In AAS, a light source (typically a hollow cathode lamp) emits light at a specific wavelength that corresponds to the electronic transitions of the element being measured. The sample is then introduced into the light path, and the absorption of the light is measured by a detector. The amount of light absorbed is proportional to the concentration of the element in the sample. AAS is a highly sensitive and selective technique for the analysis of heavy metals. It has the advantage of being able to detect trace amounts of metals in complex matrices, such as water, soil, and food samples. AAS can also be used for the analysis of multiple elements simultaneously, allowing for the efficient and accurate determination of heavy metal concentrations.

REMOVAL OF EXCESS CONTAMINATION USING NANOPARTICLES.

Nanoparticles have shown promise in various applications, including water treatment and remediation. They can be used to remove excess contaminations from water due to their unique properties such as high surface area, reactivity, and adsorption capabilities. Below given a few ways nanoparticles can be utilized for the removal of contaminants from water:

1. Adsorption: Nanoparticles can be functionalized or coated with specific materials to enhance their adsorption properties. They can effectively adsorb contaminants onto their surfaces, thereby reducing their concentration in the water. Examples of nanoparticles used for adsorption include activated carbon nanoparticles, metal oxide nanoparticles (such as titanium dioxide), and magnetic nanoparticles.
2. Catalysis: Certain nanoparticles possess catalytic properties that can facilitate the degradation or transformation of contaminants into less harmful substances. For instance, nanoscale zero-valent iron (NZVI) has been used to catalyze the reduction of chlorinated solvents, heavy metals, and organic pollutants.

PREPARATION OF ISO-CONTOUR USING GIS

GIS applications in groundwater studies include mapping and suitability analysis, assessment of groundwater flow vulnerability and their quality integrated with spatial data. The exact longitudes and latitudes of sampling points are imported in GIS platform. The spatial distribution for ground water quality parameters like hardness, pH, TDS, HCO3,SO4,NO3, Ca, Mg, Cl and F were done with the help of spatial analyst modules in ArcGIS 10.3.

The isocontour maps of each parameter is extracted from the ArcGIS software.

5. RESULTS AND DISCUSSION

ANALYTICAL ANALYSIS OF SAMPLES.

The water samples are tested for parameters in the laboratory. The concentration of the parameter are given in table 3 below.

Sample NAME	Latitude	Longitude	pH	Turbidity	Alkalinity	Chloride	EC	TDS
AS1	12.825278	77.607222	7.73	19	237	33.5	290	188.5
AS2	12.823056	77.611944	7.82	9	338	59	471	306.15
AS3	12.800278	77.604444	7.67	65	368	134	643	417.95
AS4	12.790833	77.633889	7.29	42	348	78	527	342.95
AS5	12.771111	77.633056	7.56	67	196	162	729	473.85
AS6	12.760278	77.652500	7.5	20	264	159.5	704	457.6
AS7	12.781389	77.662778	7.35	138	218	149.5	683	443.95

AS8	12.705278	77.696111	7.33	35	223	56.2	298	193.7
AS9	12.774722	77.678333	7.26	62	240	102.8	648	421.2
AS10	12.741389	77.693611	7.83	72	190	43	285	185.25
AS11	12.801944	77.677222	7.5	47	178	159.8	739	480.35
AS12	12.793889	77.653611	7.05	36	256	144	593	385.45
AS13	12.765556	77.638333	7.44	71	295	96	403	261.95
AS14	12.836944	77.610556	7.32	12	221	128.4	489	317.85
AS15	12.745000	77.658611	7.15	53	253	140.3	422	134.14
AS16	12.718056	77.682222	7.83	32	244	70.8	494	114.46
AS17	12.750000	77.720556	7.39	63	286	99.4	416	166.51
AS18	12.753333	77.737222	7.66	54	294	64.6	473	97.51
AS19	12.763611	77.746944	7.24	48	214	93.4	480	118.57
AS20	12.874085	77.692793	7.72	42	271	72.1	556	159.69
AS21	12.873659	77.679104	7.5	35	240	96.6	463	81.18
AS22	12.854047	77.695275	7.07	45	201	82.9	483	136.01
AS23	12.851219	77.718088	7.92	42	280	84.2	409	165.85
AS24	12.775556	77.754167	7.75	59	235	144.2	446	150.57
AS25	12.797500	77.740278	7.17	52	257	97.5	529	160.17
AS26	12.796667	77.725833	7.56	53	283	30.4	442	151.71
AS27	12.820556	77.732778	7.97	50	315	49.0	508	80.37
AS28	12.815000	77.704444	7.3	62	252	60.7	430	151.98
AS29	12.819690	77.726891	7.42	33	253	130.7	460	95.53
AS30	12.873038	77.783633	7.88	32	319	31.1	459	76.20
AS31	12.797400	77.778919	7.1	43	224	128.2	489	102.94
AS32	12.776861	77.738533	7.54	38	246	104.0	520	178.75
AS33	12.797319	77.743936	7.8	30	195	141.9	541	178.34
AS34	12.866278	77.710633	7.2	35	206	81.9	491	116.65
AS35	12.809592	77.688836	7.63	41	319	66.2	452	128.05
AS36	12.825647	77.698011	7.52	39	225	65.6	426	126.84
AS37	12.827369	77.688314	6.96	41	305	72.8	460	86.79
AS38	12.826992	77.666925	7.37	52	275	74.3	553	76.08
AS39	12.887156	77.680572	7.52	37	298	91.4	512	73.28
AS40	12.871883	77.768131	7.89	37	253	46.5	458	94.50
AS41	12.841097	77.780500	7.43	33	284	123.8	508	100.11
AS42	12.853264	77.790225	7.24	41	230	46.4	564	69.15
AS43	12.886111	77.790414	7.87	48	315	106.4	482	100.78
AS44	12.909692	77.783042	7.73	50	195	144.7	598	140.25
AS45	12.912411	77.810136	7.32	64	208	128.6	470	179.40
AS46	12.928947	77.772214	7.33	42	259	103.9	482	131.38
AS47	12.894553	77.815531	7.35	65	222	119.6	415	111.11
AS48	12.910525	77.761844	7.65	46	294	61.9	452	84.82
AS49	12.919050	77.763464	7.43	52	232	149.9	507	100.34
AS50	12.903817	77.756350	7.55	61	214	95.1	477	150.50

Table 3 Laboratory analytical results of surface water sample.

Sample NAME	Acidity	Total Hardness	Calcium	Megnicium	Sulphate	Iron	Nitrate	Flouride
AS1	68	156	33.67	17.5	69	0.54	0.003	0.116
AS2	64	236	45.69	29.65	70	0.34	0.05	0.026
AS3	84	252	44.89	34.02	62	0.36	0.08	0.125
AS4	128	260	48.1	34.02	32	0.96	0.068	0.287
AS5	68	288	65.73	30.13	42	2.16	3.772	0.234
AS6	120	272	55.37	32.56	45	0.55	1.453	0.07
AS7	124	248	51.3	26.16	38	1.68	0.054	0.046
AS8	66	178	35.64	18.3	35	0.38	0.043	0.119
AS9	59	284	48.72	36.4	84	0.56	0.06	0.176
AS10	83	250	38.27	28.33	72	0.58	0.365	0.275
AS11	48	244	32.22	32.27	63	0.62	1.423	0.456
AS12	74	185	44.32	34.52	48	1.25	2.225	0.264

AS13	107	153	28.74	38.98	39	0.73	0.983	0.043
AS14	126	277	56.33	26.87	45	0.63	0.763	0.053
AS15	94	201	46.10	18.16	54	0.36	0.041	0.294
AS16	66	178	53.31	18.35	69	0.22	0.120	0.250
AS17	64	232	46.94	3.96	64	0.30	0.012	0.236
AS18	70	163	43.80	19.84	62	0.35	0.082	0.234
AS19	74	222	55.50	5.11	56	0.20	0.019	0.203
AS20	66	178	35.12	18.28	70	0.17	0.192	0.132
AS21	110	206	37.41	4.89	58	0.22	0.098	0.171
AS22	92	205	50.35	16.82	58	0.13	0.072	0.242
AS23	113	213	39.96	17.41	59	0.38	0.023	0.275
AS24	61	166	48.21	2.13	68	0.36	0.025	0.104
AS25	83	154	34.80	14.29	50	0.19	0.096	0.270
AS26	116	190	42.67	5.38	62	0.17	0.020	0.165
AS27	100	234	36.78	10.69	57	0.25	0.115	0.223
AS28	99	205	54.14	17.50	64	0.19	0.093	0.132
AS29	87	202	37.95	12.42	69	0.18	0.109	0.154
AS30	85	208	58.37	14.10	59	0.35	0.085	0.102
AS31	92	244	44.25	12.93	65	0.36	0.020	0.153
AS32	114	227	38.38	20.12	54	0.21	0.019	0.129
AS33	73	238	35.39	19.97	59	0.22	0.148	0.139
AS34	78	206	30.75	15.16	64	0.40	0.143	0.185
AS35	104	157	50.97	1.23	62	0.26	0.063	0.215
AS36	120	195	33.97	18.03	59	0.33	0.044	0.244
AS37	86	170	46.91	13.85	59	0.24	0.029	0.221
AS38	71	182	41.62	11.78	50	0.14	0.102	0.230
AS39	102	246	37.96	18.41	64	0.35	0.175	0.270
AS40	110	156	59.58	1.59	54	0.33	0.018	0.233
AS41	82	200	53.60	5.06	70	0.28	0.094	0.107
AS42	77	166	48.79	11.55	61	0.23	0.161	0.104
AS43	106	187	37.16	18.83	69	0.14	0.023	0.218
AS44	66	223	57.71	10.47	61	0.18	0.196	0.261
AS45	120	162	42.58	3.96	53	0.40	0.058	0.127
AS46	93	216	51.15	17.33	60	0.33	0.083	0.151
AS47	76	202	54.52	6.99	68	0.27	0.093	0.226
AS48	90	202	45.84	9.68	65	0.17	0.009	0.214
AS49	77	198	59.55	11.73	70	0.32	0.133	0.120
AS50	109	155	58.70	18.69	67	0.28	0.006	0.249

Table 4 Laboratory analytical results of the surface water sample.

WATER QUALITY INDEX.

The water quality index (WQI) allows the reduction of vast amounts of data on a single range of physio-chemical and biological parameters to a simple Reproducible manner. WQI is calculated from the point of view of stream water quality criteria regarding all uses. Weighted Arithmetic Index Method is used to find the WQI.

Sample Name	WQI value for drinking purpose	WQI value of water for Agri and industrial purpose	Sample Name	WQI value for drinking purpose	WQI value of water for Agri and industrial purpose
AS1	145.863	67.632	AS26	90.081	162.679
AS2	90.79	36.02	AS27	109.293	160.643
AS3	143.779	194.869	AS28	101.617	184.072
AS4	269.237	142.54	AS29	74.979	106.753
AS5	568.656	206.704	AS30	114.202	103.276
AS6	150.159	69.011	AS31	124.7	132.318
AS7	510.923	386.262	AS32	86.323	120.512
AS8	122.49	109.01	AS33	83.464	99.681
AS9	188.802	187.319	AS34	126.166	112.884
AS10	204.75	223.868	AS35	101.458	133.471
AS11	196.205	166.074	AS36	117.54	130.795
AS12	329.48	122.031	AS37	96.892	131.317
AS13	233.831	204.911	AS38	83.675	162.649

AS14	160.987	44.821	AS39	120.219	126.864
AS15	136.993	169.769	AS40	125.387	125.387
AS16	112.695	112.695	AS41	96.425	103.185
AS17	126.976	192.426	AS42	123.707	123.707
AS18	170.526	170.526	AS43	81.88	155.215
AS19	93.689	148.953	AS44	161.217	161.217
AS20	131.093	131.093	AS45	151.127	188.698
AS21	86.949	113.715	AS46	131.121	131.121
AS22	143.855	143.855	AS47	125.112	197.474
AS23	133.832	143.135	AS48	147.223	147.223
AS24	174.24	174.24	AS49	123.479	155.959
AS25	96.424	164.75	AS50	191.054	191.054

WQI values of surface water samples.

Sl No.	Sample Name	WQI value for drinking purpose	WQI value for Agri and industrial purpose
1	AG1	20.414	22.253
2	AG2	17.729	19.11
3	AG3	24.683	19.053
4	AG4	13.276	18.267
5	AG5	47.017	15.89
6	AG6	37.307	20.776
7	AG7	32.059	16.553
8	AG8	31.975	18.908
9	AG9	33.013	23.626
10	AG10	37.852	24.105

WQI values of groundwater samples

The groundwater quality in the study area is considered good for both potable water and agricultural use. All groundwater samples have a WQI value of less than 50, which falls within the "excellent" range for both potable water and agricultural practice.

However, the surface water samples show different results. According to the potable water WQI classification, most of the surface water samples have a WQI value of more than 100, which indicates that the surface water is unsuitable for drinking purposes.

On the other hand, when considering the agricultural WQI classification, the surface water samples have a WQI value ranging from 100 to 200, which is classified as "poor" water quality for drinking purposes. Although it is not suitable for drinking, it can still be used for industrial and irrigation purposes.

HEAVY METAL ANALYSIS

Some selected water samples are tested for heavy metal analysis. The samples are tested for Lead, Boron, Copper, Nickel, Zink. The concentration of the of the water sample below.

Sl no	Parameter	Sample									
		AG1	AS20	AS21	AS22	AS23	AS1	AS2	AS4	AS7	AG2
1	Boron	0.62	0.62	0.37	0.33	0.34	0.53	0.4	0.34	0.43	0.54
2	Copper	0.0059	0.6535	0.0557	0.039	0.0601	0.0642	0.0634	0.0389	0.0589	0.0047
3	Nickel	0	0	0	0	0	0	0	0	0	0
4	Lead	0.0682	0.0963	0.0966	0.0731	0.0904	0.0687	0.896	0.0667	0.0785	0.0467
5	Zinc	0	0.1252	0	0	0	0.1132	0	0	0	0

In the analysis of heavy metals, the levels of Boron, Copper, Nickel, and Zinc in the tested water samples meet the established limits set by the Bureau of Indian Standards (BIS) for both drinking water and agricultural use. However, the concentration of Lead in the water samples exceeds the permissible limit set by the BIS. According to the BIS specifications, the presence of Lead in drinking water should ideally be zero, and the maximum allowable limit is 0.01 milligrams per liter (mg/L). Hence the groundwater sample is not potable.

REMOVAL OF LEAD FROM THE WATER SAMPLE USING IRON OXIDE NANOPARTICLES

A known volume of 1% Ferrous Sulfate was taken and placed on magnetic stirrer with hot plate, for the homogenization of mixture and allowed to heat till the temperature of the solution reached 60°C, after attaining the required temperature, the green tea extract filled in the burette was released drop wise slowly to the ferrous sulfate solution placed on hot plate, after gradual addition of plant extract to the ferrous sulfate iron oxide nano particles start to precipitate in black color. The precipitated nano particles were separated by centrifugation at 5000rpm for 10minutes, later the pellet (FeNp's) was washed with distilled water and further the FeNp's formed were dissolved in ethanol and kept for evaporation in hot air oven to obtain nanoparticles.
The FeNp's obtained were used for treating the water sample to remove lead.
A known volume of 1% Ferrous Sulfate was taken and placed on magnetic stirrer with hot plate, for the homogenization of mixture and allowed to heat till the temperature of the solution reached 60°C, after attaining the required temperature, the green tea extract filled in the burette was released drop wise slowly to the ferrous sulfate solution placed on hot plate, after gradual addition of plant extract to the ferrous sulfate iron oxide nano particles start to precipitate in black color. The precipitated nanoparticles were separated by centrifugation at 5000rpm for 10minutes, later the pellet (FeNp's) was washed with distilled water and further the FeNp's formed were dissolved in ethanol and kept for evaporation in hot air oven to obtain nanoparticles.
The FeNp's obtained were used for treating the water sample to remove lead.
The results of the tests are provided in the below table.

Sl no	Sample Name	Lead conc.	Pb conc. After treated with NP's
1	AG01	0.682	0
2	AS21	0.0966	0

PREPARATION OF ISOCONTOUR USING ArcGIS

The concentrations of the parameters are added in the ArcGIS software to get the isocontour maps of the concentrations of each parameter.

The spatial distribution of the concentration of parameters is extracted using an interpolation tool and then the raster map of each parameter is obtained. The raster map is used to extract the isocontour map using the contour tool in the software for each parameter.

The extracted isocontour maps are given below.

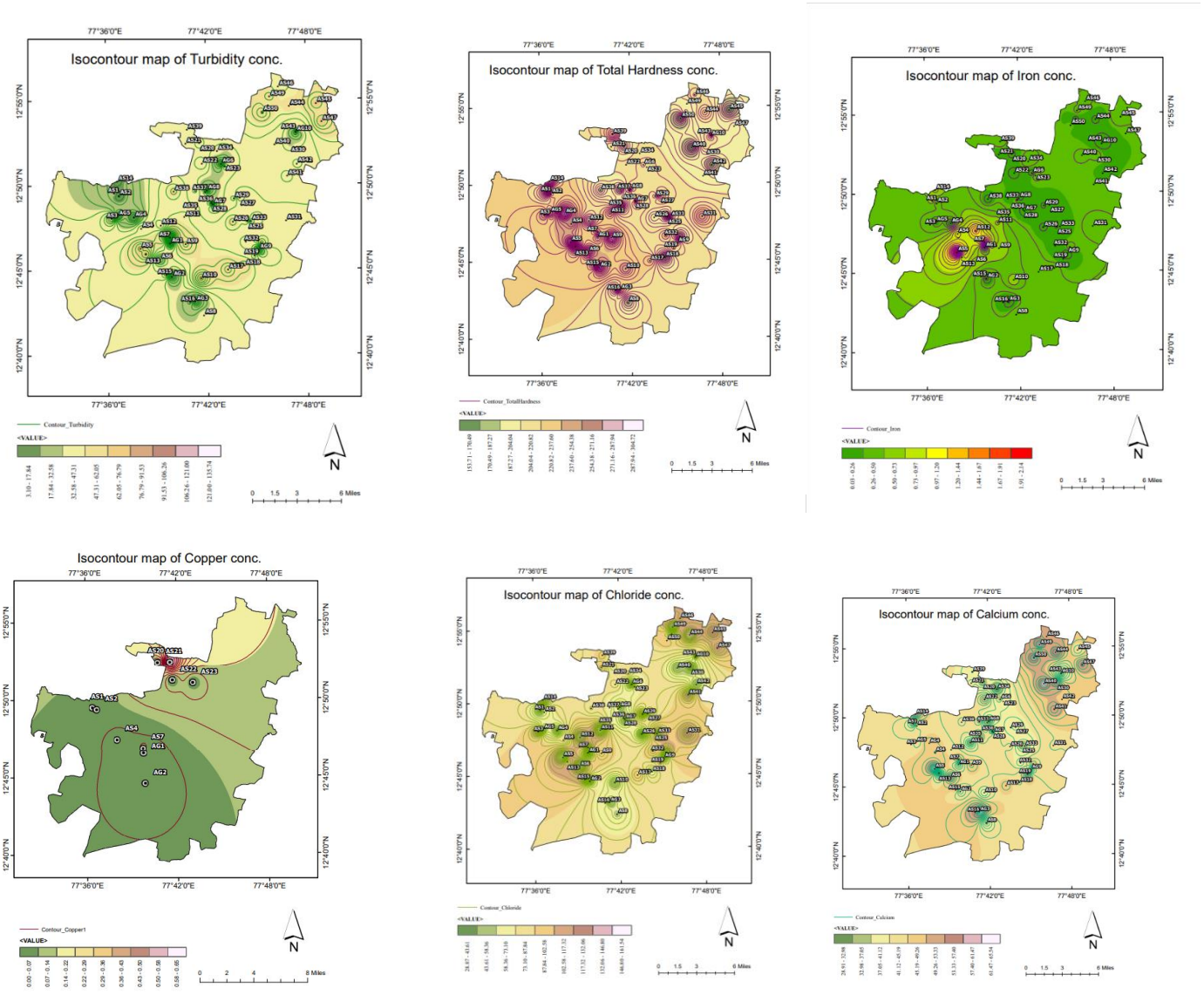

Fig Iso contour maps of Turbidity, Total hardness, Iron, Copper, Chloride, Calcium concentrations.

International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

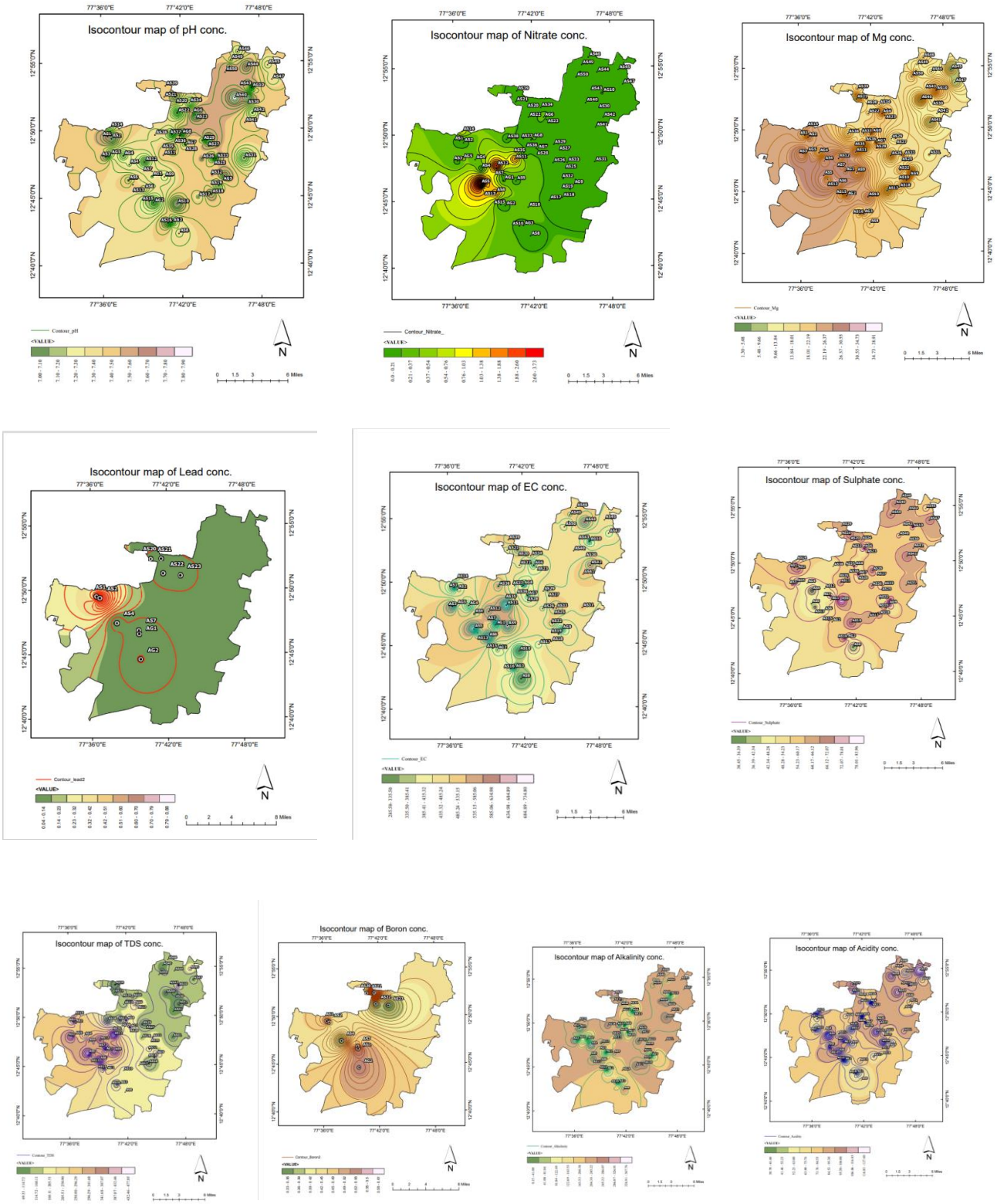

Fig Iso contour maps of pH, Nitrate, Mg, Lead, EC, Sulphate, TDS, Boron, Alkalinity, Acidity concentrations.

6. CONCLUSIONS

Based on the study conducted in the Anekal taluk, the following conclusions can be drawn:

- Groundwater Quality: The groundwater in the Anekal taluk is found to be potable based on the Water Quality Index (WQI) value being less than 50. This indicates that the groundwater is suitable for drinking purposes.
- Surface Water Quality: The surface water in the Anekal taluk is not potable, as the WQI values exceeded 100. Therefore, it is not suitable for direct consumption.
- Lead Contamination: Both the surface water and groundwater samples showed the presence of lead, although in small amounts. Remediation methods should be employed to remove or reduce the concentration of lead in the water samples to ensure the water's safety.
- Remediation Methods for Lead: The recommended remediation methods for lead removal or reduction include source removal, pump and treat, and enhanced natural attenuation. These methods aim to identify and remove the sources of lead, treat the water to remove or reduce lead concentrations, or rely on natural processes to attenuate lead levels over time.
- Water Use Recommendations: While the surface water is unsuitable for drinking purposes, it can still be used for agricultural and industrial practices. However, it is crucial to consider appropriate treatment methods for these purposes to ensure the safety and quality of water used in these applications.
- In summary, the study suggests that the groundwater in the Anekal taluk is potable, but the surface water requires remediation to address the lead contamination. Implementing suitable remediation methods will help improve the water quality and ensure its suitability for various uses.

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