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Comparative Analysis of Valleys and water quality analysis in the Valley System of Bengaluru Using RS & GIS

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Abstract Many lakes can be found in Bengaluru's three major valley systems: Vrishbhavathi Valley, Hebbal Valley, and Koramangala-Challaghatta Valley, all of which play an essential role in the city's hydrological processes. The morphometric study aids us in learning about the underlying rock type, soil perviousness, slope gradients, runoff behavior, and water retention capability within the Valley systems. Morphometric analysis is carried out for areal, Linear and relief aspects. By using GIS software, the base map and drainage maps were created with the help of topographical maps and DEM data from the Survey of India. The Strahler system of stream ranking was adopted. Among the three Valleys, in terms of area and perimeter, Vrishbhavathi Valley appears to be the largest of the three Valleys The highest stream order in the Vrishbhavathi Valley basin is sixth, while the highest stream order in the other two Valleys is fifth. The Dendritic drainage patterns were observed within the Valley systems. The drainage density of the three Valleys revealed that they are classified as coarse drainage. The three Valleys have modest reliefs, indicating a flat topography. Lake Water samples & Ground water analysis results showed that lake water samples require treatment & lie in D classification, whereas ground water samples lie well within drinking water standards.

Key Words: Valley, Lakes, Morphometry, RS & GIS, SRTM, DEM etc**,**

1. INTRODUCTION

Water is one among the foremost important resources supplied by nature, which occurs in the form of surface water and groundwater. The planet earth contains total 71% of water and 29% land. In that ocean contains 97% of the water and only 3% is fresh water. From total fresh water 30.1 percent may present in ground water and 68.6 percent may present in glaciers & ice caps.

Bengaluru formerly known as "The City of Lakes" is located in the semi-arid peninsular plateau in the south-eastern part of Karnataka. Bengaluru and surrounding region are not supported by perennial river system However, there are three major valley systems in Bangalore: Hebbal Valley, Challaghatta Valley, and Vrishbhavathi Valley, which house all of Bangalore's lakes. When one of these lakes' overflows, the surplus water cascades down to the next lake in the lower series, based on elevation. They are essential for maintaining life and ensuring groundwater recharge. They are home for several species of organisms, support biodiversity and partially caters to the water demand of the city. Bengaluru has three main valley systems namely. Hebbal, Koramangala - Challaghatta, Vrishbhavathi. (Pavitra, 2021).

Now a day valleys system & lakes in Bengaluru get destroy due to rapid urbanization, lakes are got polluted day by day due to inflow of sewage, industrial waste water to the lake without treatment, the present study is intended to understand the physical characteristics valleys using various parameters which are derived from Remote sensing & GIS. The valley system and lakes used in the study has shown peculiar physical properties, these were different from the previous studies carried out on the same valley system and lakes. The study shall be useful for the organizations which carryout programmes for conservation of valley system and lakes, taking preventive measures to control pollution of lake water and increase inflow, storage capacity, quality control, public usage. Ground water management is very essential nowadays due to increase in depletion of ground water. hence study concentrated on following objectives:

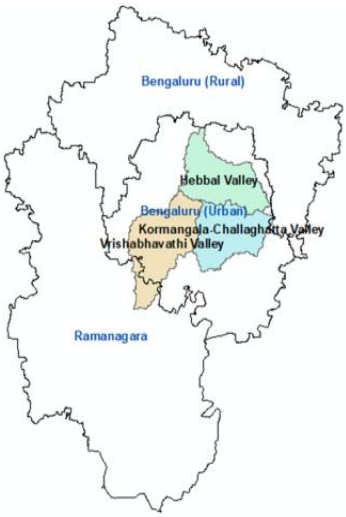
- Preparation of base maps to understand the characteristics of the Valley systems in the study area.
- Morphometric analysis of the valley systems in Bengaluru.
- Physico- chemical analysis of water quality in the selected lakes of valley system in Bengaluru.
- Ground water quality analysis for the sampling points selected around the lakes in the valley system.
- Comparative analysis of valley system & Physico-chemical parameters of the lake water & their surrounding ground water in the study area.

1.1 Study Area

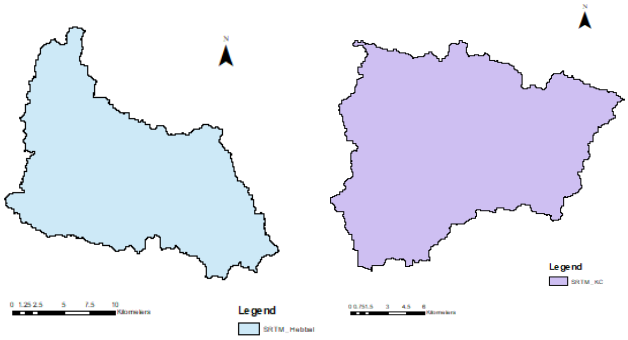
Bengaluru lies in the southeast of the South_Indian state of Karnataka. It is at an average elevation of 900 m (2,953 ft). It is located at 12.97°N 77.56°E and covers an area of 741 km^2 (286 sq m) (M. Inayathulla,2012).

The study area chosen is different valley system in Bengaluru, district, Karnataka. There is main three valley system in Bengaluru such as Vrishbhavathi valley, Hebbal valley, & Koramangala valley (Www. Wikipedia.com).

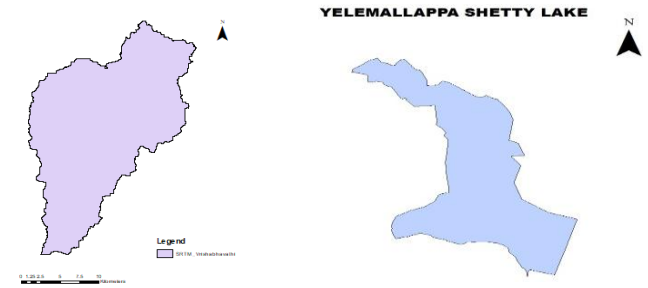
The valleys spread in Bangalore urban and Bangalore rural district, the Vrishbhavathi valley lies geographically between $77^0$58'0" E longitude and $12^0$30'0" N latitude. It has covers surface area of 380 km^2. and Koramangala valley lies geographically between77^0.93'00" E longitude and 12^0.93'00" N latitude. It has surface area of 288.68km^2. and the Hebbal valley lies geographically between 77^0.59'00" E longitude and 13^0.03'00" N latitude. It has covered an area of 308.26km^2. and carried out experiment of characteristics of water quality parameters of three lakes such as Yelemallappa Shetty Lake & Byramangala lake & Madiwala lake in each valley. Fig 1 shows study area map (Pavitra, 2021).



HEBBAL VALLEY **K-C VALLEY**



V- VALLEY YELEMALLAPPA LAKE



BYARAMANGALA LAKE **MADIWALA LAKE**

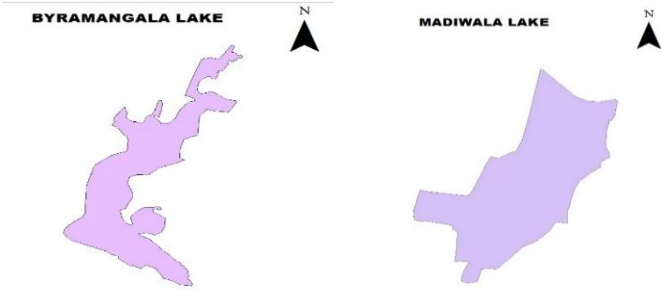


Fig. 1: Valley System & Lakes in the Study Area

2. Materials and Methodology

2.1 Preparation of base map:

A digital base map is a primary element for developing a geographic information system for organized urban development. Base map forms the framework for overlaying other relevant details related to infrastructural, land base utility networks, property details, roads network railway lines, water bodies etc. To create any intelligent GIS map (Aside et al, 2017)

The Survey of India (SOI) Topographical map of 1:50,000 scale used to digitize road network, railway lines, water bodies and major landmarks using QGIS Software. Fig 2 shows the Base map

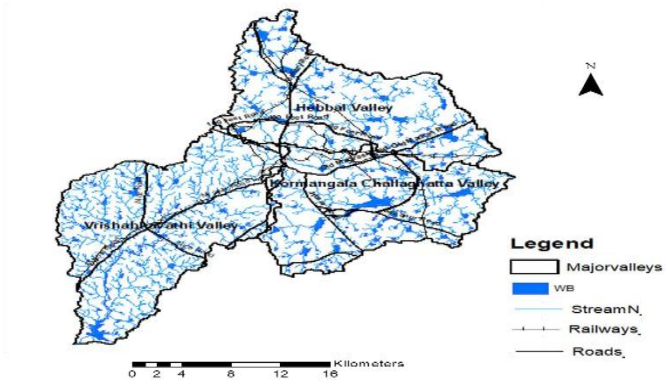


Fig. 2: Base Map

3 MORPHOMETRICAL ANALYSIS

Morphometry is the science of measuring and analysing the earth's surface, shape, and measurements. The word morphometry comes from the Greek word "morphometry," which meaning "earth measurement." (Strahler, 1964). Table 1 shows the formula to calculate morphometric parameters.

SL. No	Morphometric Parameters	Formula	source
	Linear Aspects		
1	Stream Order (Su)	Hierarchical rank	Strahler (1964)
2	Stream Number (NU)	Nu = N1 +N 2 +N3 + --- + Nn	-
3	Mean Bifurcation ratio (Rb)	Rb = Nu / Nu+1	Schumn (1956)
4	Stream length (Lu)km	Lu = L1 +L 2 + ---- + Ln	Horton (1964)
	Areal aspects		
5	Watershed Length, Lb(km)	-	-
6	Watershed Area, A(Sq.km)	-	
7	Watershed Perimeter, P (km)	-	-
8	Shape factor (Sf)	Sf= Lb^2/A	-
9	Elongation ratio (Re)	Re = (2/Lb) * (A/π) ^0.5	Schumn (1956)
10	Circularity ratio (Rc)	Rc = $4\pi A/P^2$	Miller (1953)
11	Stream frequency (Fs)	Fs = Nu / A	Horton (1964)
12	Drainage density (Dd)km/km2	Dd = Lu /A	Horton (1964)
13	Constant of channel maintenance	C =1/Dd	Schumn (1956)
	Relief Aspects		
14	Height of watershed mouth, (m)	-	-
15	Maximum height of the watershed(m)	-	-
16	Total basin relief (H) m	H=Z-z	Schumn (1956)
17	Relief ratio (Rh)	Rh = H / Lb	Schumn (1956)
18	Form factor ratio (Ff)	Ff = A/ Lb^2	Horton (1964)
19	Ruggedness number (Rn)	Rn = (Dd* H)/1000	Schumn (1956)

3.1 PHYSICO-CHEMICAL ANALYSIS LAKE WATER & THEIR SURROUNDING GROUND WATER:

The steps followed for the Collection of samples in the selected lakes & there surrounding ground water –

- Selection of lakes such as 1. Yelemallappa lake, 2. Byaramangangala lake, 3. Madiwala lake, & their surrounding ground water of lakes, these lakes are selected because these are major lakes in each valley & lakes are located at the tip of each valley.
- The plastic cans were used to carry the samples.5 samples from each lake & 2 samples of ground water surrounding each lake
- The bottles were tightly closed after collection.
- The collected Lake water & ground water samples were analysed to determine pH, Turbidity, Temperature, total solids, total suspended solids, total dissolved solids, COD, BOD, DO, TH, Ca hardness, mag hardness, Chloride, Total Alkalinity, Iron.
- All the listed parameters were analysed as per APHA (American Public Health Association) standard methods 2012. & Compared with drinking water standards (BIS 10500:2012) & lake water standards (ISI- 2296).

4. RESULTS AND DISCUSSION

4.1 MORPHOMETRY

In the present study, the Vrishbhavathi Valley is measured as the largest Valley in terms of area and perimeter. It has sixth order stream as its highest order where as Hebbal and Koramangala-Challaghatta Valleys have fifth order stream as their highest order. The total number of streams respectively in the V-Valley are 853, in the Hebbal Valley 381 and in K-C Valley 395. The stream order map of the three Valleys is shown in the below figures 3, 4, and 5 respectively and the stream order numbers are represented in the table 2. The bifurcation values calculated for all the three Valleys stay within normal values indicating less structural disturbance and are tabulated in table 2. All the three Valleys exhibit a dendritic drainage pattern. The pattern of the drainage formed in the study area shows well integrated pattern formed by a main stream with its tributaries branching and re-branching freely in all the directions. The dendritic drainage pattern indicates the semi-pervious nature of the soil. The stream lengths, mean stream lengths and stream length ratios calculated for the three major Valley system are mentioned in the table 3.

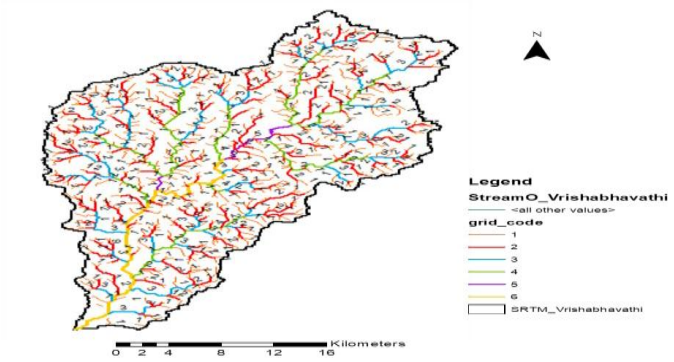


Fig 3: Stream order map: Vrishbhavathi Valley

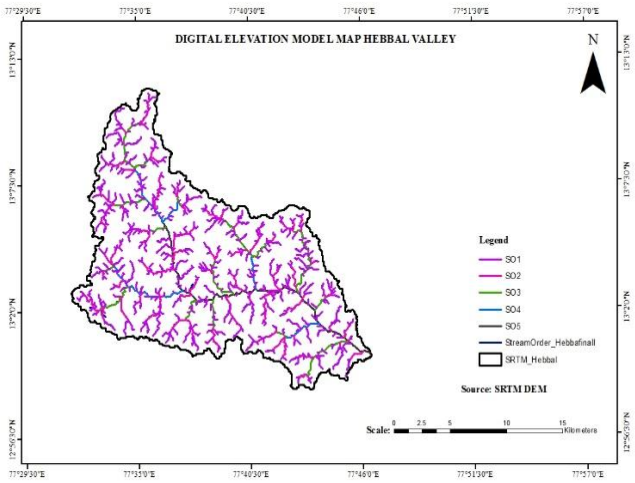


Fig 4: Stream order map- Hebbal Valley

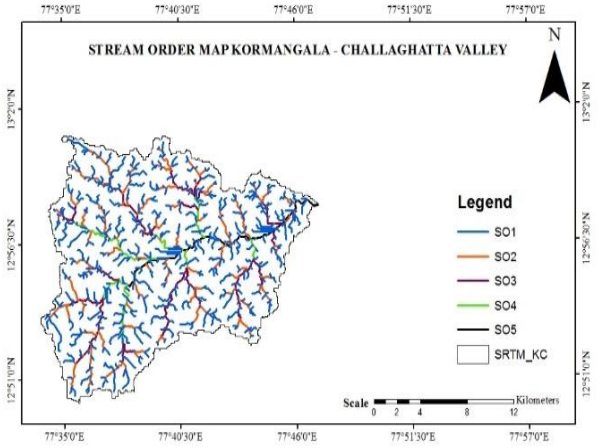


Fig 5: Stream order map- Koramangala Valley

Table 2: Bifurcation Ratios of the major valley system

Stream Order	Vrishbhavathi Valley		Hebbal Valley		Koramangala Valley	
-	Number of streams	Bifurcation ratio	Number of streams	Bifurcation ratio	Number of streams	Bifurcation Ratio
1	638	3.867	288	4.000	300	4.220
2	165	4.230	72	4.800	71	4.176
3	39	4.875	15	3.000	17	2.833
4	8	4.000	5	5.000	6	6.000
5	2	2.000	1	-	1	-
6	1	-	-		-	-

Table 3: Stream lengths and Mean stream lengths of the Major Valley Systems

Stream order	Vrishbhavathi valley				Hebbal valley				Koramangala valley			
	Number of streams	Stream length (Kms)	Mean stream length	Length ratio	Number of streams	Stream length (Kms)	Mean stream length	Length ratio	Number of streams	Stream length (Kms)	Mean stream length	Length ratio
1	638	361.700	0.567	-	288	173.080	0.601	-	300.000	192.061	0.640	-
2	165	169.570	1.028	0.469	72	92.820	1.289	0.536	71.000	89.510	1.261	0.466
3	39	80.330	2.059	0.474	15	47.400	3.160	0.511	17.000	54.504	3.206	0.609
4	8	65.640	8.205	0.817	5	20.220	4.044	0.427	6.000	27.380	4.563	0.502
5	2	7.500	3.750	0.114	1	25.610	25.610	1.267	1.000	20.136	20.136	0.735
6	1	23.203	23.230	3.094	-	-	-	-	-	-	-	-
Cumulative length (Kms)	-	707.97	-	-	-	359.13	-	-	-	383.59	-	-

4.1.1 LINEAR ASPECTS

The characteristics of the drainage basin are discussed below.

a. Stream order (Nu): The stream order map of the three different valleys such as Vrishbhavathi valley, Hebbal valley, & K-c valleys are shown in the figures 3, 4, and 5 respectively and table 2

shows stream orders of the three valleys of Bengaluru. From the Fig 3, it can be observed that Vrishbhavathi Valley has a steam order of 6 and Fig 4 & 5 shows that Hebbal valley and K-C Valleys has a stream order of 5. Stream order & number of streams of V-Valley, Hebbal valley, & K-C valley is shown in Table 2

b. Bifurcation ratio (Rb): The mean bifurcation ratios for the Vrishbhavathi valley are 3.8, Hebbal Valley is 4.2 and Koramangala-Challaghatta Valley is 4.30. The Rb Values stay within normal values indicating less structural disturbance and bifurcation ratio values as shown in the table 3.

c. Stream length ratio: Stream length ratio of the different valley are shows in table 4
The stream length ratio of V- Valley is 3.094 at 6th stream order, & the stream length of Hebbal valley is 1.267 at 5th & The stream length ratio of K- C Valley is 0,735 at 5th stream order. 1st stream order

4.1.2 AREAL ASPECTS

a. Area and Perimeter: Table 4 shows the area of V-valley are 380.5 Sq.kms and perimeter of V- valley are 134.36Kms. The area of Hebbal valley is 308.26 Sq.kms and perimeter of Hebbal valley are 131.80Kms. The area of K-C Valley are 288.68 Sq. Kms and perimeter of K-C Valley are 117.51 Kms respectively.

b. Drainage Pattern: drainage pattern of all three valleys are Dendritic Drainage pattern.

c. Watershed shape factor: The watershed shape factor has impact on the sediment transport process & runoff. The shape of the catchment governs the rate of water enters the stream. The quantitative expression of watershed can be characterized as form factor, and elongation ratio, compaction coefficient, & circularity ratio.

d. Form factor (Rf): It is clear that the form factor value of Vrishbhavathi Valley is 0.323, Hebbal Valley is 0.401 and Koramangala Valley is 0.461. All the three Bangalore valleys are elongated and flow for longer duration.

e. Compactness coefficient (Cc): Table 4 shows the compactness coefficient for different valleys such as Vrishbhavathi Valley is 3.120, Hebbal Valley is 2.479 and K-C Valley is 2.153. The results indicate Vrishbhavathi Valley is elongated and other two Valleys such as Hebbal & K-C valley is comparatively less elongated than the Vrishbhavathi Valley.

f. Circularity ratio (Rc**)**: From the table 4 it is clear that the Circularity ratio value ranges between 0.2 to 0.8. inferior circularity ratio (Rc) values show strongly or exclaim elongated basin. The value of Circularity ratio for Vrishbhavathi Valley is 0.364, Hebbal Valley is 0.222 and Koramangala Valley is 0.257. the values of all of the valley's values indicate that the valleys are elongated.

i. Elongation ratio (Re): From the table 4 it can be observed that the elongation ratio value of Vrishbhavathi Valley is 0.6641, which valley indicates that the valley is elongated. The elongation ratios value of Hebbal is 0.715, this valley indicates that valleys are less elongated. and the elongation ratio of Koramangala Valley is 0.767 which indicates that K-C valleys are less elongated.

j. Drainage density: Table 4 shows the the values drainage density obtained for Vrishbhavathi valley is 1.860 Km/Sq.km, The values drainage density obtained for Hebbal Valley is 1.165 Km/Sq.km and the values drainage density obtained for Koramangala valley is 1.328 Km/Sq.km. From the result all the three values have low drainage density which may be due to low relief and permeable sub-soil materials. From the result, we can decide that Vrishbhavathi valley, Hebbal Valley and K-C valley. basins have coarse to very-coarse drainage texture. five classes of drainage density for different textures as classified by Horton (1932).

k. Drainage texture: Table 4 shows the value of the drainage density obtained for Vrishbhavathi valley is 6.348 /Km, Hebbal Valley is 2.890 /Km and Koramangala valley is 3.361 /Km. Smith has classified five classes for drainage texture i.e., below 2 very coarse, 2-4 for coarse, 4-6 for moderate, 6-8 for fine and above 8 for very fine. The Vrishbhavathi -Valley indicates moderate to fine drainage texture and Hebbal valleys indicates coarse drainage texture. & K-C valleys indicates coarse drainage texture. Low value indicates low risk of soil erosion.

l. Constant of channel maintenance (c): from the table 4 it is clear that the value of Constant of channel maintenance for Vrishbhavathi valley is 0.537 Sq.km/km, Hebbal Valley is 0.857 Sq.km/km and Koramangala valley is 0.752 Sq.km/km. The values depend on rock permeability, vegetation and rainfall duration.

m. Stream frequency (Sf): from the 4 shows that the study area of Vrishbhavathi valley stream frequency is 2.241, & study area of Hebbal Valley stream frequency is 1.235 and study area of Koramangala valley stream frequency is 1.368. The stream frequency of the study exhibits low values and indicates a positive correlation drainage density.

4.1.3 RELIEF ASPECTS: Relief aspects are an important factor in understanding the extent of denudation process undergone within the catchment and it is indicator of flow direction of water.

a. Watershed relief (H): from the table 4 it is clear that the total relief calculated for the delineated Vrishbhavathi valley basin is 0.280Kms, Hebbal Valley is 0.095Kms and Koramangala-Challaghatta valley is 0.105Kms. All the three Valleys have low reliefs indicating almost a flat surface as a whole.

b. Relief ratio (Rh): Table 4 shows the value of the relative ratio for Vrishbhavathi valley is 0.008, Hebbal Valley is 0.003 and Koramangala valley is 0.004. The results show that the Slope in the Valley regions vary from nearly level to gentle slope or very gentle slope.

c. Relative relief (Rr): Table 4 shows the relative relief value of Vrishbhavathi valley is 0.002, Hebbal valley is 0.001 and Koramangala valley is 0.001. The results show that the Slope in the Valley regions vary from nearly level to gentle slope or very gentle slope. (In few points within the valley we can notice moderate slope and steep slope.**).**

d. Ruggedness number (Rn): Table 4 shows the value for Vrishbhavathi valley is 0.520, Hebbal valley is 0.110 and Koramangala valley is 0.139. Low values of ruggedness number indicate low relief and coarse drainage density.

Table 4: Morphometric parameters of the three major valley system

Sl no	parameters	unit	Hebbal valley	Koramangala valley,	Vrishbhavathi valley.
1	Area of delineated valley	Sq.kms	308.26	288.68	380.5
2	perimeter	Kms	131.80	117.51	134.36
3	Highest stream order	-	5	5	6
	Total number of streams	-	381	395	853
	Frist order stream	-	-	-	638
	Second order stream	-	288	300	165
	Third order stream	-	72	71	39
	Fourth order stream	-	15	17	8
	Fifth order stream	-	5	6	2
	Sixth order stream	-	1	1	1
4	Basin elongation	Kms	27.7	25	34.3
5	Cumulative stream length	Kms	707.97	359.13	383.59
6	Length of overland flow	Sq.km/Kms	0.256	0.436	0.363
7	Drainage density	Km/Sq.km	1.165	1.328	1.860
8	Constant of channel maintenance	Sq.km/km	0.857	0.752	0.537
9	Stream frequency	No/Sq.km	1.235	1.368	2.241
10	Mean bifurcation ratio	-	4.20	4.30	3.75
11	Drainage texture	Per Km	2.890	3.361	6.348
12	Form factor	-	0.401	0.461	0.323
13	Basin shape	-	2.489	2.165	3.091
14	Circulatory ratio	-	0.222	0.257	0.364
15	Elongation ratio	-	0.715	0.767	0.641
16	Total relief	Kms	0.095	0.105	0.280
17	Relief ratio	-	0.003	0.004	0.008
18	Relative relief	-	0.001	0.001	0.002
19	Ruggedness number	-	0.110	0.139	0.520
20	Drainage intensity	-	1.060	1.029	1.204

4.2 PHYSICO-CHEMICAL ANALYSIS LAKE WATER & THEIR SURROUNDING GROUND WATER:

Table 5,6 & 7 shows the Physico chemical parameters

Table 5. shows the Values of Different Parameters of Yelemallappa Shetty lake water & surrounding Groundwater with location.

Sl. no	Parameters	Methods	Units	Standards	Months during which the sample is collected							
					Sample in march-25-2021							
					Surface water					Ground water		
					Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Standards	Sample1	Sample2
1	pH	Digital pH meter	-	6.5-8.5	7.6	7.2	7.6	7.7	7.5	6.5-8.5	6.5	6.8
2	Turbidity	Nephleon meter	NTU	5 NTU	28.9	28	23.1	23.6	20.2	5 NTU	0.4	0.1
3	Temperature	Thermometer	Celcius	_	22.5	22	23.1	23.5	23.1	_	_	_
4	Electric conductivity	Conductivity meter	µs/cm	2250 µs/cm	873.5	893	954	898	892.5	300 µs/cm	1211	1137
5	Chlorides	Titration method	mg/l	250 mg/L	256	246	232	230	226	250 mg/l	660	596
6	Total solids	Filter paper method	mg/l	_	772	964	710	720	716	_	_	_
7	Total dissolved	Filter paper	mg/l	_	458	644	534	478	582	_	1408	728
8	Total suspended	Filter paper	mg/l	_	314	320	176	242	134	_	_	_
9	COD	COD digester	mg/l	250 mg/L	384	352	416	608	416	250 mg/L	_	_
10	DO	Winkler's method	mg/l	6.0 mg/L	3	2.8	2	2	2.3	5.0 mg/L	_	_
11	BOD	Dilution method	mg/l	2 mg/L	13.2	14.8	25.2	15.6	42	30 mg/L	_	_
12	Alkalinity	Titration method	mg/l	250 mg/L	104	100	100	102	108	250 mg/L	218	212
13	Total hardness	EDTA method	mg/l	300 mg/L	300	268	292	260	256	300 mg/L	628	612
14	Ca hardness	EDTA method	mg/l	_	208	186	228	220	228	_	448	460
15	Mg hardness	EDTA method	mg/l	_	92	82	64	40	28	_	180	152
16	Iron	_	mg/l	0.3mg/L	0.1	0.2	0.36	0.54	0.68	0.3		

Table 6. shows the Values of Different Parameters of Byramangala lake water & surrounding Groundwater with Location

Sl. no	Parameters	Methods	Units	Standards	Months during which the sample is collected							
					Sample in April-7-2021							
					Surface water					Ground water		
					Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Standards	Sample1	Sample2
1	pH	Digital pH meter	-	6.5-8.5	7.5	7.34	7.2	7.3	7.5	6.5-8.5	6.95	6.15
2	Turbidity	Nephleon meter	NTU	5 NTU	19	37.2	27.8	35.2	27.3	5 NTU	0.4	0.2
3	Temperature	Thermometer	Celcius	_	22	22.4	22	21.8	21.7	_	_	_
4	Electric conducti	Conductivity meter	µs/cm	2250 µs/cm	947	1042	998	937	904	300 µs/cm	983	858
5	Chlorides	Titration method	mg/l	250 mg/L	200	196	208	210	206	250 mg/l	482	458
6	Total solids	Filter paper method	mg/l	_	650	724	792	452	604	_	_	_
7	Total dissolve	Filter paper	mg/l	_	500	410	506	406	450	_	728	510
8	Total suspend	Filter paper	mg/l	_	150	214	286	146	154	_	_	_
9	COD	COD digester	mg/l	250 mg/L	280	268	212	208	220	250 mg/L	_	_
10	DO	Winkler's method	mg/l	6.0 mg/L	3.2	2.9	3.8	2.2	2.3	5.0 mg/L	_	_
11	BOD	Dilution method	mg/l	2 mg/L	15.1	26	23.6	22.4	26.4	30 mg/L	_	_
12	Alkalinity	Titration method	mg/l	250 mg/L	136	116	112	120	128	250 mg/L	212	216
13	Total hardnes	EDTA method	mg/l	300 mg/L	260	204	200	232	200	300 mg/L	512	588
14	Ca hardnes	EDTA method	mg/l	_	216	192	172	196	176	_	400	496
15	Mg hardnes	EDTA method	mg/l	_	44	12	28	36	24	_	112	92
16	Iron	_	mg/l	0.3mg/L	0.45	0.23	0.5	0.34	0.58	0.3		

Table 7. shows the Values of Different Parameters of Madiwala lake water & surrounding Groundwater with Location

Sl. no	Parameters	Methods	Units	Standards	Months during which the sample is collected							
					Sample in Sep-22-2021							
					Surface water					Ground water		
					Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Standards	Sample1	Sample2
1	pH	Digital pH meter	-	6.5-8.5	7.2	7.2	7.5	7.5	7.6	6.5-8.5	7.16	6.89
2	Turbidity	Nephleon meter	NTU	5 NTU	31	31.7	28	13.6	25.1	5 NTU	0.3	0.2
3	Temperature	Thermometer	Celcius	_	20.5	20.1	20.4	20.4	20.2	_	_	_
4	Electric conductivity	Conductivity meter	µs/cm	2250 µs/cm	456	422	427	485	472	300 µs/cm	432	499
5	Chlorides	Titration method	mg/l	250 mg/L	160	152	156	112	118	250 mg/l	416	436
6	Total solids	Filter paper method	mg/l	_	760	764	600	710	800	_	_	_
7	Total dissolved	Filter paper	mg/l	_	615	613	481	570	627	_	748	715
8	Total suspended	Filter paper	mg/l	_	145	151	119	140	172	_	_	_
9	COD	COD digester	mg/l	250 mg/L	120	152	156	188	184	250 mg/L	_	_
10	DO	Winkler's method	mg/l	6.0 mg/L	3.9	3.5	3.1	3.9	4.1	5.0 mg/L	_	_
11	BOD	Dilution method	mg/l	2 mg/L	15.2	18.8	20	16.4	22.8	30 mg/L	_	_
12	Alkalinity	Titration method	mg/l	250 mg/L	128	120	112	120	140	250 mg/L	218	224
13	Total hardness	EDTA method	mg/l	300 mg/L	252	236	196	204	212	300 mg/L	576	552
14	Ca hardness	EDTA method	mg/l	_	176	148	104	108	148	_	392	380
15	Mg hardness	EDTA method	mg/l	_	76	88	92	96	64	_	184	172
16	Iron	_	mg/l	0.3mg/L	0.24	0.3	0.42	0.16	0.42	0.3		

a. LAKE WATER & GROUND WATER RESULTS

- From the lake water analysis, it is observed in all lake water samples parameters such as Temperature, pH, chloride, Alkalinity, DO, these parameters found to be within drinking water standards, and turbidity EC, COD, BOD, TS, TSS, TDS, TH, all parameters exceed Drinking standards standards permissible limits as per water (IS 10500: 2012).
- From drinking water standards, the lake water is not suitable for drinking purpose because maximum parameters exceed drinking water standards, hence required treatment.
- All the lakes lie in class D classification lake water standards (ISI-2296).
- From the Ground water analysis, it is observed the Ground water surrounding all lakes samples parameters such as pH, turbidity, chloride, Alkalinity, TDS all parameters lie within drinking standards, And EC, TH, all parameters exceed Drinking standards (IS 10500: 2012).
- From drinking water standards, the Ground water is suitable for drinking purpose because Physico chemical parameters lie within drinking water standards.

5. CONCLUSIONS

1. The area of V- valley are 380.5 Sq.kms and perimeter of V- valley are 134.36Kms. The area of Hebbal valley is 308.26 Sq.kms and perimeter of Hebbal valley are 131.80Kms. The area of K-C Valley are 288.68 Sq. Kms and perimeter of K-C Valley are 117.51 Kms respectively

2. Drainage density value obtained for Vrishbhavathi valley is 1.860 Km/Sq.km, Hebbal Valley is 1.165 Km/Sq.km, Koramangala valley is 1.328 Km/Sq.km.

- From the result all the three valleys have low drainage density which may be due to low relief and permeable sub-soil materials. It can be stated that Vrishbhavathi valley, Hebbal Valley and K-C valley basins have coarse to very-coarse drainage texture.

3. The Circularity ratio value ranges between 0.2 to 0.8. inferior circularity ratio (Rc) values show strongly or exclaim elongated basin.
- The value of Circularity ratio for Vrishbhavathi Valley is 0.364, Hebbal Valley is 0.222 and Koramangala Valley is 0.257. The values of all of the valley's values indicate that the valleys are elongated.

4. Mean bifurcation ratios for the Vrishbhavathi valley are 3.8, Hebbal Valley is 4.2 and Koramangala-Challaghatta Valley is 4.30. The Rb Values stay within normal values indicating less structural disturbance.

5. The lake water analysis shows that, the Physico chemical parameters does not lies within the permissible standards of drinking water (IS 10500: 2000) except pH, EC, chlorides etc. hence it requires treatment before use.

6. As per Lake water standards (ISI- 2296), lake water lies in class D.

7. The Ground water analysis shows that, the Physico chemical parameters lies within the permissible standards of drinking water (IS 10500: 2000), hence it is suitable for drinking purposes.

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