International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-6, Issue-9)

Research Article | **September 2017**

Spatial and Temporal variation analysis of water quality of Hemavathi River, Karnataka, India

Santhosh K. M
Department of Civil Engineering, VTU, RRC, Belgaum, Karnataka, India

Dr. S. Prashanth
Professor and HOD, Department of Civil Engineering, G.E.C, Hassan, Karnataka, India

Abstract:

Urban development, agricultural runoff and industrialization have contributed pollution loading on the environment. In this study Hemavathi river water from a stretch from its origin point to its sangama was studied for pollution load by determining parameters of water quality like pH, Alkalinity, Ca, Mg, Nitrate, TDS, BOD, COD , and the results were compared with WHO and BIS standards to draw final conclusion on the quality of water.

Keywords: River Hemavathi, pH, Ca, Mg, TDS

I. INTRODUCTION

Water is unlike other scarce resources, important in several respects. It underpins all aspects of human society, from ecology to agriculture to industry and it has no known substitutes. Like air, it is fundamental to life. Water, in the form of rain and snow, is made available by nature through the hydrological cycle. An appreciable part of it gets lodged in snowcaps and natural lakes and is subsequently utilizable, in case of the former through snowmelt reaching a river system. A sizeable part is retained in surface soils and used up through evapotranspiration for biomass generation. Another part seeps into the ground feeding natural aquifers. A major part appears in the river system downstream and is drained into seas, unless captured in man-made storages or artificially diverted from natural courses. Water is recycled continuously through transpiration, biomass and evaporation from land, river systems and oceans, besides precipitation through condensation, rain and snow. A river basin is a natural entity for planning beneficial uses of available waters from precipitation, which are highly variable in space and time.

According to **WHO, (2003)** one billion people worldwide still lack adequate supply of clean drinking water and nearly two billion people do not get water for proper sanitation. Pathogen contamination of aquatic ecosystems is known to occur from a range of sources including municipal wastewater effluents, agricultural wastes, and wildlife (**Environment Canada, 2001**). Water pollution is a major problem in developed countries and the severity is still more in developing countries like India. Today water resources have been most exploited due to increasing population, industrialization, urbanization, increasing living standards and broad spheres of human activities. In India, major rivers, such as Ganga, Yamuna, Tapti, Godavari, Narmada, Krishna, Cauvery and many other rivers are severely polluted (**Sharma, 2005**).

II. STUDY AREA

Background

The Hemavati River starts in the Western Ghats at an elevation of about 1,219 metres near Ballala rayana durga in the Chikmagalur District of the state of Karnataka, in southern India. It flows through Hassan District where it is joined by its chief tributary, the Yagachi River, and then into Mandya district before joining the Kaveri near Krishnarajasagara. It is approximately 245 km long and has a drainage area of about 5,410 km².

2.1 Sampling location of study area

Hemavathi River from its origin point Javali to Sangama near in Karnataka spread over 245 km(Karnataka State Gazeteer, Part one, 1982) long in length was chosen as study area. Seventeen locations were selected based on domestic, agricultural and industrial activities in the vicinity of river basin, recreation and ritual practices. Geographical details of the sampling locations are given in Table 2.1. Water samples were collected for physico-chemical analysis, Chemical analysis, Nutrients and Bacteriological count from each sampling point during pre-monsoon, monsoon and post-monsoon for from February 2014 to January 2016. This research work involves 17 sampling stations Hemavathi River shows in the Table 3.1

Table No.2.1: Sampling stations during the study period.

Sl. No.	Sampling Stations	Locations	Latitude	Longitude
01	S1	JAVALI	13.16718 N	75.49421E
02	S2	BANAKAL	13.13483 N	75.54546E
03	S3	BETTAGERI BRIDGE	13.12952N	75.58501 E
04	S4	KITTALEGANDI	13.09758N	75.60784 E
05	S5	HANTHOOR BRIDGE	13.07195 N	75.63900 E
06	S6	CHIKOODIGE	13.04288 N	75.71771 E
07	S7	HENNALE	12.96321 N	75.76536 E
08	S8	SAKLESHPURA	12.94320 N	75.85524 E
09	S9	K.HOSAKOTE	12.82788 N	75.85524 E
10	S10	GORURU	12.81741 N	76.06117 E
11	S11	MARGONDANAHALLY	12.81269 N	76.18222 E
12	S12	HOLENARASIPURA	12.79660 N	76.24433 E
13	S13	DODDAGANNI	12.83896 N	76.33637 E
14	S14	GONDIHALLY	12.81257N	76.33637 E
15	S15	MANDAGERE	12.73368 N	76.37612 E
16	S16	DODDAHALLY	12.62840 N	76.41537 E
17	S17	SANGAMA	12.520124 N	76.438539 E

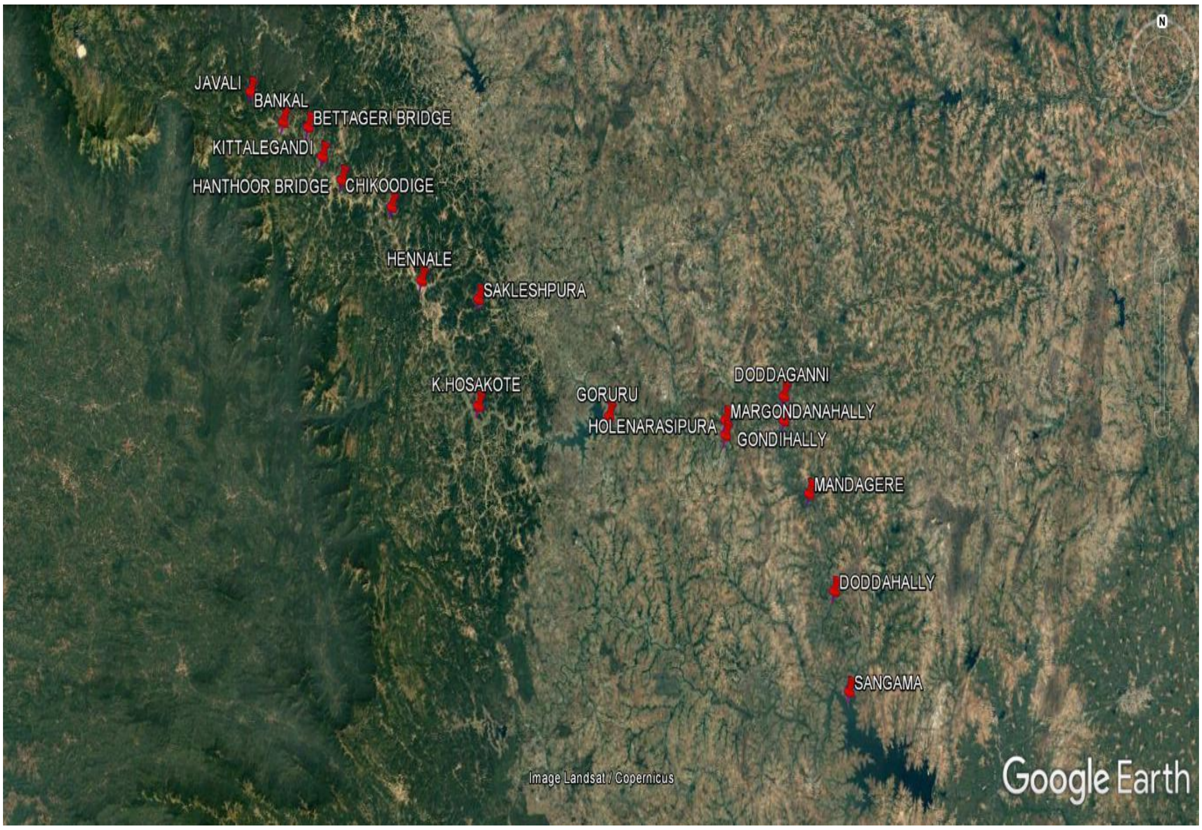

Figure 2.1: Sampling location of the study area

III. MATERIALS AND METHODS

3.1 Sampling Techniques

The collected samples were kept in 2L polythene plastic bottles cleaned with metal free soap water, rinsed many times with distilled water and finally soaked in 10% nitric acid for 24 h and rinsed with ultrapure water in the end. All the water samples were stored in insulated cooler containing ice and delivered on the same day to laboratory and maintained at 4℃ until processing and analysis as suggested in Kazi et al. (2009). Water samples were analyzed for pH, Turbidity, Electrical conductivity (EC), Total dissolved solids (TDS), Calcium(Ca), Magnesium(Mg), sulfate(SO_4), Flouride (F), nitrates(NO_3), chlorides (Cl), Iron(Fe), sodium (Na), Alkalinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), Total Coliform, E-coli and Pesticides.

3.2 Physico-chemical parameters

Water samples were collected for physico-chemical analysis, Chemical analysis, Nutrients and Bacteriological count from each sampling point during pre-monsoon, Monsoon and post-monsoon from February 2014 to January 2016. Samples were collected in pre-cleaned polypropylene bottles of two liter capacity. For finding out amount of dissolved oxygen, water samples were taken in 300 ml BOD bottles and fixed immediately using Winkler's reagent and brought to the laboratory

Table 3.1 Methods adopted for groundwater analysis

Sl. No.	Parameters	Method (APHA,1998)	Instruments used
Physical			
1	Turbidity	Photometric	Digital Nephelo - Turbidity meter model 132 (Systronics)
2	Total dissolved solid	Electrometric method	EC- TDS analyzer - Microprocessor based (ELICO - CM 183)
3	Electrical conductivity		
4	pH	Electrometric	pH pen
Chemical			
5	DO	Winkler's Iodometric method	
6	BOD	Winkler's Iodometric method	
7	Calcium	APHA method	
8	Magnesium		
9	Total Alkalinity		
10	Chloride		
11	Sulphate	Spectrophotometer method	
12	Fluoride		
13	Iron		
Nutrients			
14	Nitrate	Spectrophotometer method	Colorimetric
15	Sodium	Flame Photometer	
16	Pesticides	Gas Chromotagraphy	
Bacteriological			
17	E. coli	Membrane filter technique	Membrane filter
18	Total coliform	Membrane filter technique	Membrane filter

IV. RESULTS AND DISCUSSION

The seasonal averages of physico-chemical and bacteriological characteristics are given in Table 4.1 , Table 4.2 and Table 4.3 respectively.

Table 4.1 Pre-Monsoon

Sample No	pH	Turbidity	Conductivity	Total Dissolved Solids	Total Hardness	Calcium as Ca^{2+}	Magnesium as Mg^{2+}	Sulphate as SO_4^{2-}	Fluoride as F^-	Nitrate as NO_3^-	Chloride as Cl^-	Iron as Fe^{2+}	Sodium as Na^+	B.O.D (3days)	Dissolved Oxygen (DO)	Total Alkanity as Calcium carbonate	Pesticides	Total Coliform	E- coli
1	7.2	0.09	51	37	14	3.2	1.45	BDL	BDL	BDL	13.4	BDL	3.6	0	6.5	20	Absent	<1	0
2	7.26	0.09	92.7	61	32	8	2.91	1.1	BDL	0.44	17.22	BDL	6.8	0	6.1	29	Absent	1	Absent
3	7.28	0.1	97.3	67	32	6.4	3.88	1.1	BDL	0.19	17.22	0.01	8	0	6	38.5	Absent	<1	Absent
4	7.24	0.03	98	58	32	6.4	3.88	BDL	BDL	0.35	17.22	BDL	7.6	0	6.1	23	Absent	1	Absent
5	7.23	0.1	102	63	32	4.8	4.86	BDL	BDL	0.16	13.4	0.01	7.2	0	6.4	23	Absent	<1	Absent
6	7.28	0.12	95.2	67	32	6.4	3.88	1.2	BDL	0.54	19.14	0.04	8	0	7	24	Absent	1	Absent
7	7.46	0.16	114.3	74	36	8	3.88	0.6	0.17	0.51	15.31	BDL	9.6	0	6.9	21	Absent	<1	Absent
8	7.76	0.35	106.9	76	48	8	6.8	BDL	BDL	0.7	17.22	BDL	9.2	0	6.1	11	Absent	<1	Absent
9	7.66	0.41	121	77	44	11.2	3.88	1.3	BDL	0.73	17.22	BDL	7.6	0	6.6	26	Absent	2	Absent
10	7.58	0.4	152.6	94	72	16	7.77	5.11	BDL	0.44	19.14	BDL	11.2	0	6.6	40	Absent	<1	Absent
11	7.63	0.24	140.7	88	52	12.8	4.86	2.4	0.75	0.38	19.14	BDL	11.2	0	7	44	Absent	<1	Absent
12	8.04	0.48	161.7	112	52	16	2.91	3.61	0.03	BDL	19.14	BDL	10	0	6.6	30	Absent	<1	Absent
13	8.11	0.49	195	129	76	20.8	5.83	5.51	0.13	0.44	19.14	BDL	13.6	6	5.1	78	Absent	<1	Absent
14	8.5	0.64	239.5	161	128	25.6	15.55	7.01	BDL	0.76	21.05	BDL	16	0	6.4	92	Absent	<1	Absent
15	8.54	0.8	259	157	124	24	15.35	6.51	0.4	0.41	21.05	BDL	17.2	3	4.8	84	Absent	<1	Absent
16	8.54	0.9	259	168	148	24	21.38	12.08	BDL	0.6	21.05	BDL	17.2	12	4.8	92	0	<1	Absent
17	8.70	1.30	570	391	216	57.6	17.49	26.07	BDL	0.89	30.62	BDL	32.4	ND	4.8	144.00	Absent	<1	Absent

Table 4.2 Monsoon

Sample No	pH	Turbidity	Conductivity	Total Dissolved Solids	Total Hardness	Calcium as Ca^{2+}	Magnesium as Mg^{2+}	Sulphate as SO_4^{2-}	Fluoride as F^-	Nitrate as NO_3^-	Chloride as Cl^-	Iron as Fe^{2+}	Sodium as Na^+	B.O.D (3days)	Dissolved Oxygen (DO)	Total Alkanity as Calcium carborate	Pesticides	Total Coliform	E- coli
1	6.90	0.63	25	18.10	22	BDL	BDL	BDL	BDL	BDL	14.21	BDL	4.1	0	6.6	22	Absent	1	Absent
2	7.12	0.72	39	42.10	34	4.34	2.43	1.56	BDL	0.48	19.24	BDL	7.2	0	6.8	30.2	Absent	1	Absent
3	7.17	0.75	36	48.1	4207	4.82	3.21	1.81	BDL	0.34	18.21	BDL	8.1	0	6.4	31.6	Absent	1	Absent
4	7.18	0.82	42	28.4	38.2	4.80	3.42	1.34	BDL	0.24	19.15	BDL	7.8	0	6.9	27.4	Absent	1	Absent
5	7.21	0.92	61	39.6	36.1	5.12	4.38	2.36	BDL	0.19	15.20	BDL	8.2	0	6.8	28.4	Absent	1	Absent
6	7.16	1.12	32	41.3	44	5.41	4.12	3.47	BDL	0.48	16.32	BDL	8.6	0	6.5	32.6	Absent	1	Absent
7	7.28	0.73	50	42.6	45	5.72	4.21	3.89	0.17	0.61	14.31	BDL	9.23	0	6.6	29.5	Absent	1	Absent
8	7.41	0.67	56	42.2	49.6	5.83	5.20	4.23	BDL	0.69	16.72	BDL	9.30	0	6.7	32.1	Absent	1	Absent
9	7.35	0.71	47	46.9	55.2	6.56	4.36	3.74	BDL	0.68	18.24	BDL	8.21	0	6.5	29.4	Absent	1	Absent
10	7.27	0.95	76	41.7	68.2	6.32	6.89	4.93	BDL	0.52	20.14	BDL	11.6	0	6.4	37.2	Absent	1	Absent
11	7.29	1010	72	42.5	61.2	6.74	5.74	3.57	BDL	0.32	20.14	BDL	12.8	0	6.9	39.6	Absent	1	Absent
12	7.61	1.24	79	64.3	76.2	7.24	4.22	5.23	BDL	BDL	21.24	BDL	12.36	0	6.5	42.1	Absent	1	Absent
13	7.63	1.12	84	51.5	82.4	7.35	5.12	6.12	BDL	0.32	24.20	BDL	14.21	0	6.2	52.3	Absent	1	Absent
14	7.90	1.12	81	72.8	109.6	7.31	8.34	6.35	BDL	0.68	25.10	BDL	17.23	0	6.7	92.5	Absent	1	Absent
15	7.87	1.23	94	79.4	112.8	8.12	7.14	6.47	BDL	0.52	29.35	BDL	19.40	0	6.2	89.6	Absent	1	Absent
16	7.78	1.25	92	73.6	138.4	8.34	7.36	7.23	BDL	0.61	28.51	BDL	19.73	0	6.7	93.6	Absent	1	Absent
17	7.81	1.68	114	135.1	182.2	11.25	9.46	10.31	BDL	0.72	31.54	BDL	26.34	0	6.1	146.2	Absent	1	Absent

Table 4.3 Post-Monsoon

Sample No	pH	Turbidity	Conductivity	Total Dissolved Solids	Total Hardness	Calcium as Ca^{2+}	Magnesium as Mg^{2+}	Sulphate as SO_4^{2-}	Fluoride as F^-	Nitrate as NO_3^-	Chloride as Cl^-	Iron as Fe^{2+}	Sodium as Na^+	B.O.D (3days)	Dissolved Oxygen (DO)	Total Alkanity as Calcium carborate	Pesticides	Total Coliform	E- coli
1	7.16	1.23	74	42	28.0	7.00	2.4	1.68	BDL	BDL	16.80	BDL	5.2	ND	6.45	26.0	Absent	1	Absent
2	7.24	1.38	129	53.8	37.0	8.92	3.74	2.86	BDL	0.59	21.2	BDL	7.8	ND	6.24	36.1	Absent	1	Absent
3	7.23	1.37	133	79.8	53.4	10.90	4.06	3.45	BDL	0.48	21.80	BDL	8.67	ND	6.24	42.6	Absent	1	Absent
4	7.16	1.40	106	63.6	35.6	7.10	4.20	3.46	BDL	BDL	20.80	BDL	8.95	ND	6.10	32.6	Absent	1	Absent
5	7.14	1.41	152	86.7	46.0	8.50	6.12	7.20	BDL	BDL	17.30	0.01	9.12	ND	6.26	40.8	Absent	1	Absent
6	7.20	1.39	146	89.1	52.0	9.04	7.16	7.45	0.11	BDL	17.02	BDL	9	ND	6.98	48.3	Absent	1	Absent
7	7.34	1.40	153	94.8	58.4	9.30	7.46	9.15	0.21	BDL	17.10	BDL	9.48	ND	BDL	38.6	Absent	1	Absent
8	7.52	1.47	159	96.8	59.6	10.80	7.56	9.24	0.21	0.78	17.80	BDL	9.35	ND	BDL	46.3	Absent		Absent
9	7.61	1.49	184	119.5	61.6	11.56	8.14	9.78	0.00	0.78	19.60	BDL	10.6	ND	BDL	38.9	Absent	1	Absent
10	7.43	1.57	193	112.8	60.8	10.90	8.02	9.21	BDL	0.41	20.80	BDL	12.9	1.20	6.54	58.6	Absent	1	Absent
11	7.56	1.58	194	116.5	64.0	14.40	7.40	9.45	0.45	0.37	21.80	BDL	15.2	ND	6.87	49.6	Absent	1	Absent
12	7.82	1.62	221	128.5	86.4	23.30	6.80	10.20	0.06	0.28	24.80	BDL	14.7	ND	5.87	54.5	Absent	1	Absent
13	7.94	1.65	228	132.2	91.2	23.50	7.82	11.89	BDL	0.57	28.50	BDL	19.2	6.50	5.67	86.5	Absent	1	Absent
14	8.24	1.77	238	154.7	117.0	24.20	13.20	12.30	BDL	0.81	31.80	BDL	19.8	1.8	5.87	99.2	Absent	1	Absent
15	8.38	1.86	314	204.1	149.5	26.90	19.90	16.10	0.21	0.65	40.60	BDL	23.5	4.20	5.90	98.6	Absent	1	Absent
16	8.38	1.98	327	189.6	151.2	27.10	19.90	12.08	0.24	0.81	42.30	BDL	20.6	6.80	6.21	109.6	Absent	1	Absent
17	8.62	2.10	423	258.3	176.0	47.80	15.10	0.23	BDL	0.92	36.40	BDL	45.2	2.5	6.14	151.0	Absent	1	Absent

4.1 Physical parameters

4.1.1 pH

pH, an indicator of acidity is a measure of water's ability to neutralize base and formulate a close relationship among carbonates, bicarbonates, calcium and free carbon dioxide. The hydrogen and hydroxide ions control variables in aqueous systems as they influence both physico-chemical and biological processes in the aquatic ecosystem. The equilibrium between these two ionic species is influenced by reactions with acids and bases introduced into the aqueous system.

Most of the Indian waters are alkaline (pH more than 7.00), compared to west flowing rivers, east flowing rivers which show moderate to high conductivity. In contrast to west flowing rivers the well waters in the basin of east flowing rivers are more alkaline (**CWC, 2006**). Many investigators have recorded alkaline condition in the riverine waters (**Khaiwal *et al* 2003; Rajput *et al* 2004;**).

During the present study, the pH ranged from a minimum of 7.2 at station 1 to a maximum of 8.70 at station 17 during pre-monsoon season (Table 4.1). The pH varied a minimum of 6.9 at station 1 to maximum of 7.87 at station 15 during Monsoon season (Table 4.2). The pH varied a minimum of 7.10 at station 1 to a maximum of 8.62 at station 17 during post monsoon season (Table 4.3). As per the WHO standards pH for aquatic life is in the range of 6.5-9.0 and for drinking purpose the standard is 6.5-8.5.

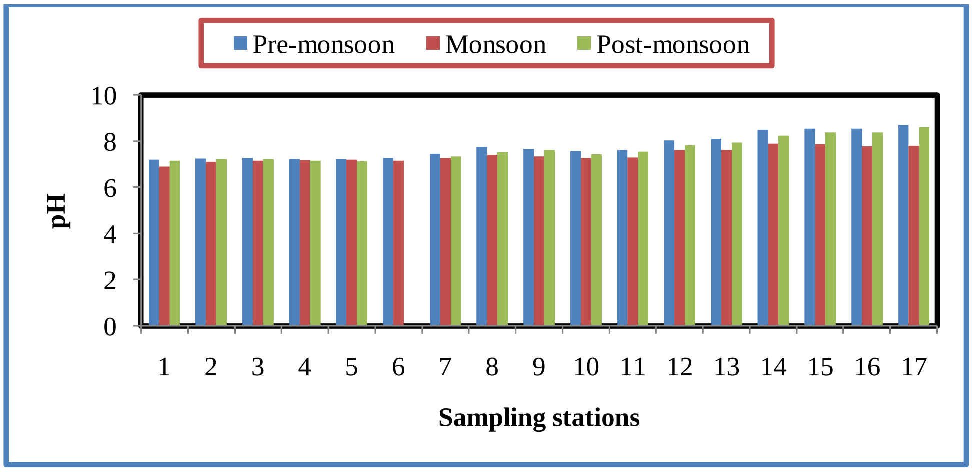

Figure 4.1: Seasonal variation of pH in Hemavathi River

4.1.2 Turbidity

Turbidity in natural water arises due to the presence of suspended particles like clay, silt, and finely divided organic and inorganic particles. It is a measure of the cloudiness of water. Under flood condition and soil erosion, great amounts of top soil are washed into receiving streams.

Turbidity values ranged between 0.03 NTU at station 1 to 1.30 at station 17 NTU in the present study, during the pre-monsoon season (Table 4.1) and 0.63 NTU at station 1 to 1.68 NTU at station 17 in monsoon season (Table 4.2) and 1.23 NTU at station 1 to 2.10 NTU at NTU at station 17 post-monsoon (Table 4.3).

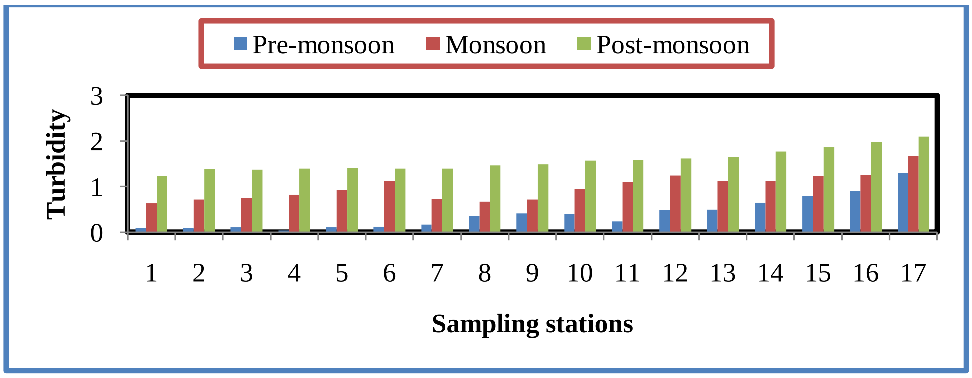

Figure 4.2: Seasonal variation of Turbidity in Hemavathi River

4.1.3Electrical conductivity (EC)

Conductivity is the ability of a substance to conduct electricity. The conductivity of water is more or less a linear function of the concentration of dissolved ions. Conductivity itself is not a human or aquatic health concern, but because it is easily measured, it can serve as an indicator of other water quality problems. If the conductivity of a stream suddenly increases, it indicates that there is a source of dissolved ions in the vicinity.

Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. **Rao *et al* (1990)** have noted the lowest electrical conductivity values during monsoon season and highest during pre-monsoon season in respect of Ganga river water.

In the present study, the values of electrical conductivity ranged between a minimum of 51 µmhos/cm at station 1 to a maximum of 570 µmhos/cm at station 17 in pre-monsoon (Table 4.1), a minimum of 25 µmhos/cm at station 1 to a maximum of 114 µmhos/cm at station 17 in monsoon season (Table 4.2) and a minimum of 74 µmhos/cm at station 1 to a maximum of 1860 µmhos/cm at station 17 in post-monsoon (Table 4.3).

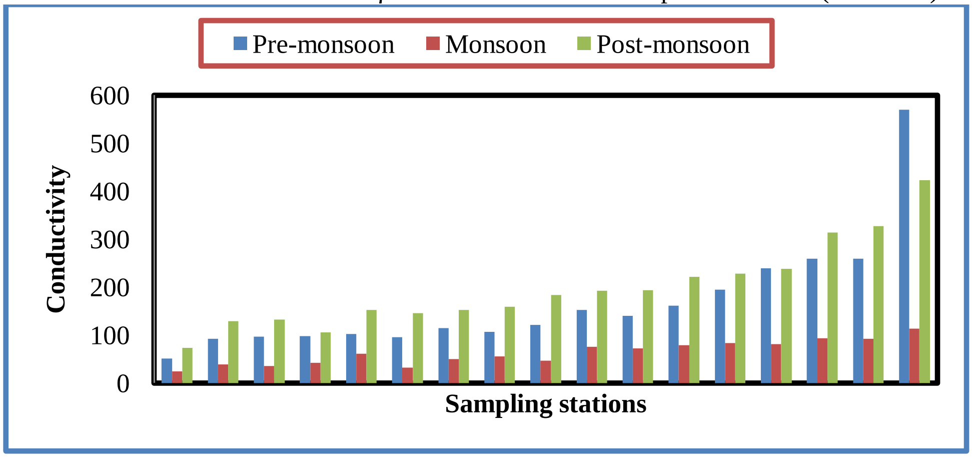

Figure 4.3: Seasonal variation of Conductivity in Hemavathi River

4.1.4 Total dissolved solids (TDS)

TDS is a measure of the solid materials dissolved in the river water. This includes salts, some organic materials, and a wide range of other materials from nutrients to toxic materials. A constant level of minerals in the water is necessary for aquatic life. Concentrations of total dissolved solids that are too high or too low may have limited the growth and lead to the death of many aquatic life forms.

In the present investigation, the TDS values varied between 37 mg/L at station 1 to 391 mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 18. mg/L at station 1 to 135.1 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 42 mg/L at station 1 to 258.3 mg/L at station 17 (Table 4.3).

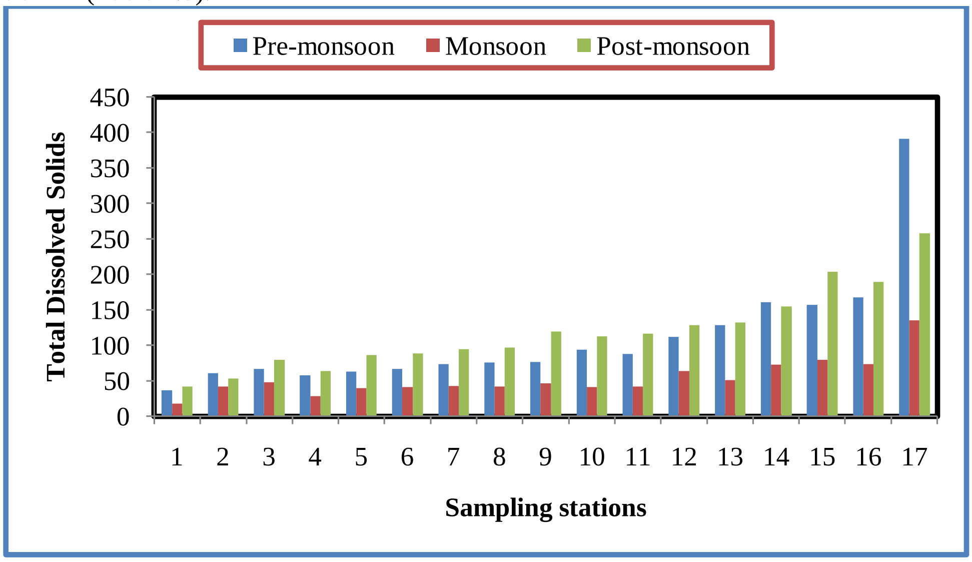

Figure 4.4 Seasonal variation of TDS in Hemavathi River

4.2 Chemical parameters

4.2.1 Total Hardness (TH)

Total hardness is one of the important constituents considered in assessing the potability of water. The hardness of water may be temporary or permanent. Temporary hardness is mainly due to the presence of bicarbonates of calcium and magnesium. The permanent hardness is due to carbonates, sulphates and chlorides of calcium and magnesium. Total Hardness is determined as $CaCO_3$ mg/L. TH caused due to cations of calcium, magnesium, iron and strontium.

The degree of hardness has been classified in term of equivalents of calcium carbonate concentration (Kotaiah & Kumaraswamy :1994:APHA,2005) as,

Soft	0 – 50 mg/L
Medium	50 – 150 mg/L
Hard	150 – 300 mg/L
Very hard	greater than 300 mg/L

In the present investigation, the Total hardness values varied between 14.0 mg/L at station 1 to 216.0 mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 22.0 mg/L at station 1 to 182.2 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 28.0 mg/L at station 1 to 176.0 mg/L at station 17 (Table 4.3). **Paula *et al* (2003)** and **Rajurkar *et al* (2003)** are of the opinion that the content of total hardness in fresh water particularly rivers is variable and low.

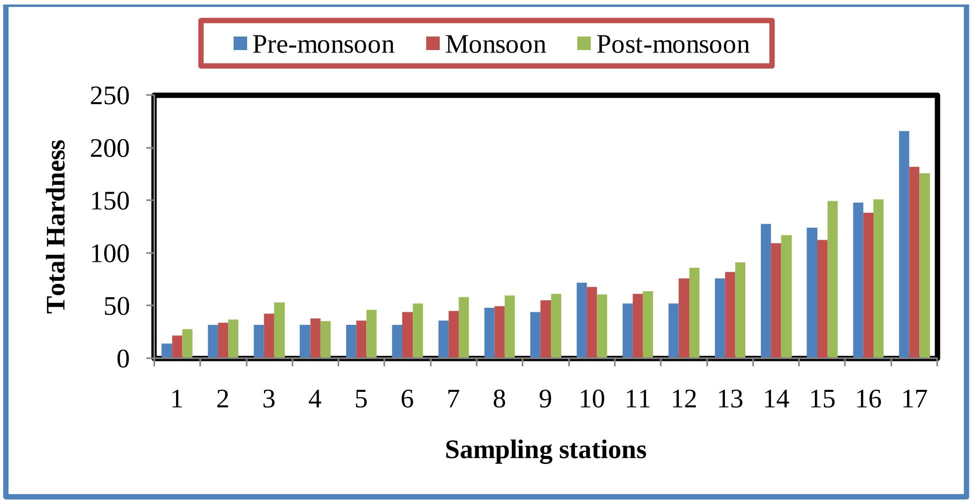

Figure 4.5 Seasonal variation of Total Hardness in Hemavathi River

4.2.2 Calcium (Ca^{2+})

Calcium is found abundantly in all natural waters and its source lies in the rocks from which it is leached. Its concentration varies in natural waters depending upon the nature of the river basin. Calcium is an important micronutrient in the aquatic environment. Water receives calcium leached from the rocks and other deposits like limestone, dolomites, calcite, gypsum, amphiboles, feldspar and clay minerals leaching or weathering of igneous rocks. Sewage and industrial waste are also important sources of calcium (**Mishra** and **Saxena, 1992**). Largely the levels of calcium and magnesium salts regulate hardness of water body. Hardness is usually expressed as an equivalent of $CaCO_3$ and varies according to local conditions. It is an indicator of water buffering capacity and productivity.

In the present investigation, the calcium concentration values varied between 3.2 mg/L at station 1 to 57.6 mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 3.60 mg/L at station 1 to 11.25 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 7.0 mg/L at station 1 to 47.80 mg/L at station 17 (Table 4.3).

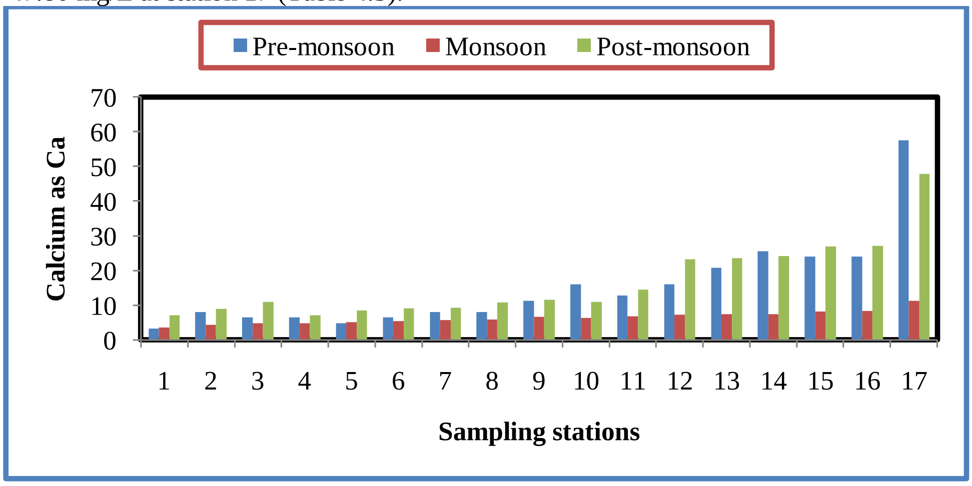

Figure 4.5 Seasonal variation of Total Hardness in Hemavathi River

4.2.3 Magnesium (Mg^{2+})

Magnesium arises principally from the weathering of rocks containing ferromagnesium minerals and some carbonate rocks. It is generally in lesser concentration than calcium. Its mineral sources are amphiboles, olvine, pyroxenes, dolomite, magnesite and clay minerals.

Magnesium is an essential constituent of chlorophylls of plant leaves without which no ecosystem exist and high content in domestic water lowers its utility. (**Manivasakam**, **1987**). High concentration of magnesium may cause laxative effects (**Kaushik et al., 2002**). Many investigators are of the opinion that magnesium always occurs in lower concentration than calcium (**Birsal *et al* 1985; Kamran Tassaduque *et al* 2003; Mishra** and **Sahoo, 2003**).

In the present investigation, the Magnesium concentration values varied between 1.45 mg/L at station 1 to 21.38 mg/L at station 16 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 2.43 mg/L at station 1 to 9.46 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 2.4 mg/L at station 1 to 19.90 mg/L at station 16 (Table 4.3).

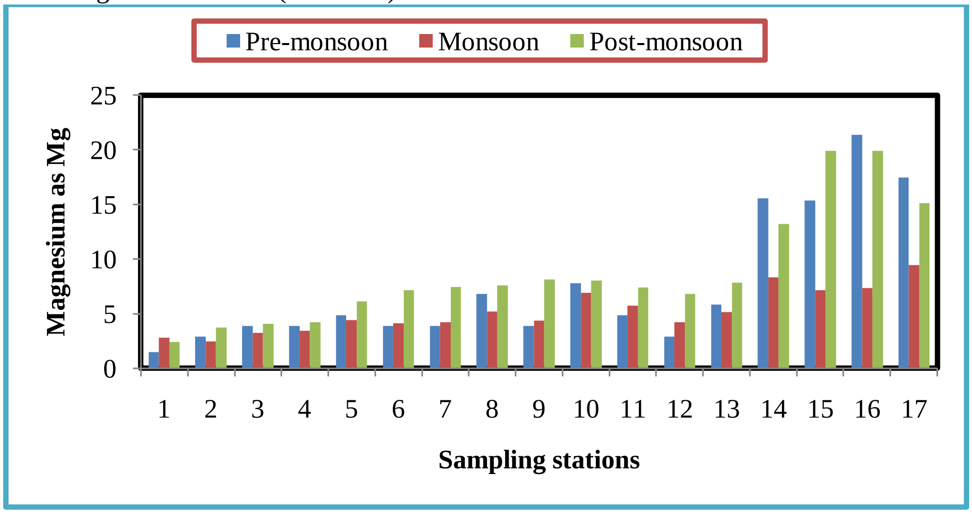

Figure 4.6: Seasonal variation of Total Hardness in Hemavathi River

4.2.4 Sulphates ($S0_4{}^{2-}$)

Sulphate is one of the major anions, which appear to be dominant in the aquatic system. The sulphate content in natural water is an important consideration in determining the suitability of water for potable purpose or industrial usage. Sulphates in natural water system may find its origin both from natural such as leaching from rocks with deposition of gypsum ($CaSO_4.2H_2O$), oxidation of organic materials from household origin as well as industrial sources.

In the present investigation, the Sulphate concentration values varied. In many sampling points the values were Below detectable limits (BDL). The values varied from Below detectable Limit (BDL) at station 1 to 26.07 mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between BDL at station 1 to 10.31 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 1.68 mg/L at station 1 to 12.30 mg/L at station 4 (Table 4.3).

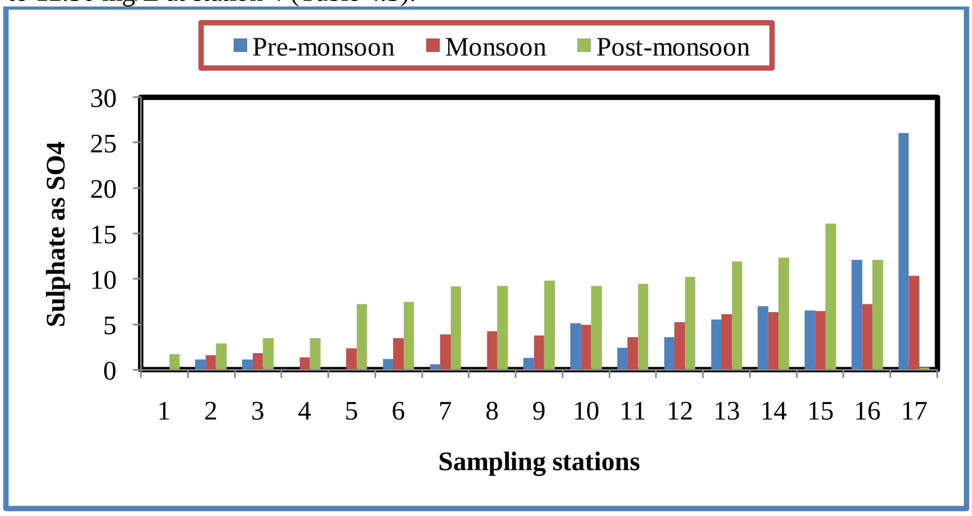

Figure 4.7: Seasonal variation of Total Hardness in Hemavathi River

4.2.5 Fluorides (F^-)

Fluoride is widely dispersed in nature and is a common constituent of most the soils and rocks. The most important fluoride containing mineral is fluorospar, which may have a variety of tints (blue, yellow and green).Fluoride enters the environment through natural and anthropogenic sources. The chief sources of fluoride are minerals viz., (fluoride, fluorapatite, micas and horneblende rocks and sediments. Fluoride bearing minerals occur in all geological formations such as sedimentary, metamorphic and igneous deposits (Hem, 1985).

The high levels of fluoride concentration in water causes mottling of teeth, bending of vertebral column, skeletal fluorosis, deformation of knee joints and other bone disorders of the body and even cause paralysis (**Sudharshan and Rajeshwara, 1991**). High level fluoride also affects economically important plants and animals.

In the present investigation, the Fluoride concentration values varied. In many sampling points the values were Below detectable limits (BDL). The values varied from Below detectable Limit (BDL) at station 1 to 0.75 mg/L at station 11 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between BDL at station 1 to 0.17 mg/L at station 7 (Table 4.2) and in post-monsoon season, it ranged from BDL at station 1 to 0.45 mg/L at station 11 (Table 4.3).

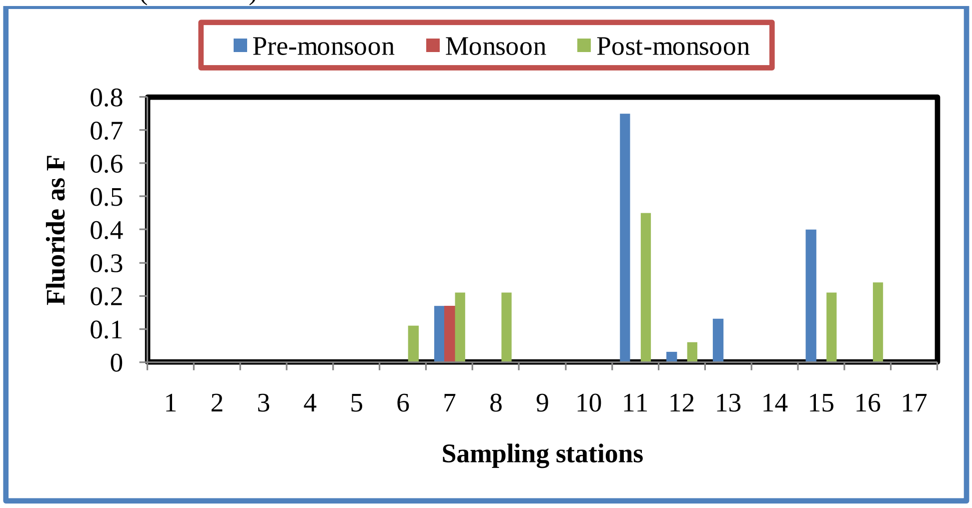

Figure 4.8: Seasonal variation of Total Hardness in Hemavathi River

4.2.6 Nitrates (NO_3^-)

Nitrate plays an important role in drinking water as it affects adversely on health at certain concentrations. Nitrate is basically non-toxic but when ingested with food or water it will be reduced by bacterial action. Nitrates are produced during the final stage of decomposition of organic matter. Presence of nitrate in water indicates contamination by runoff containing fertilizer or human and animal wastes. Nitrates from sources such as animal and human wastes, nitrogen fertilizer, crop residues and industrial wastes may move considerable distances in the ground.

In the present investigation, the Nitrate concentration values varied. In few sampling points the values were below detectable limits (BDL). The values varied from Below detectable Limit (BDL) at station 1 to 0.89mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 0.19 mg/L at station 5 to 0.72 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from BDL at station 1 to 0.92 mg/L at station 17 (Table 4.3).

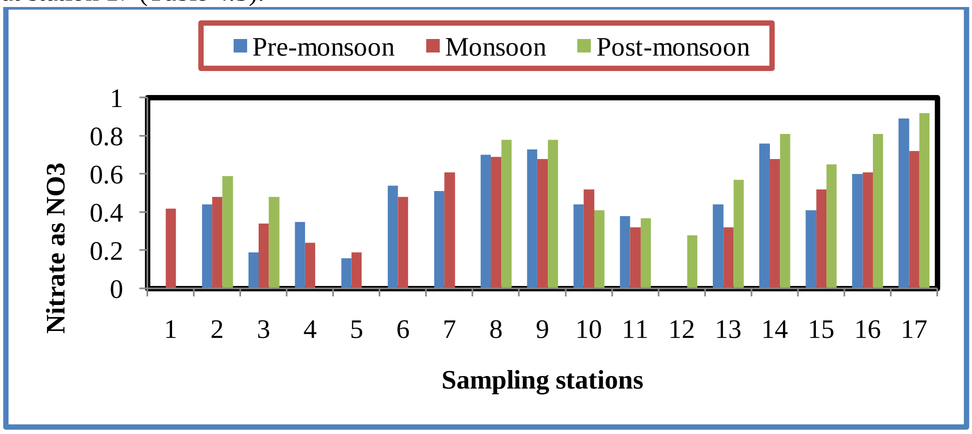

Figure 4.9: Seasonal variation of Total Hardness in Hemavathi River

4.2.7 Chlorides (Cl^-)

Chloride is a conservative type of pollutant and is very useful in water quality assessment. Chloride occurs in all types of water in a low concentration. The chloride content increases as the mineral contents increase. Chloride ion is generally present in natural water and its presence can be attributed to the dissolution of salt deposits, discharge of effluents from chemical industries, oil wells, sewage discharges, irrigation drainage and contamination from refuge leachates. The salty taste produced by chloride ion depends on chemical composition of the water (**Kumara, 2002**).

Chloride level of water indicates the pollution degrading of water (**Hasalam, 1991**). It is found in the form of Na^+, K^+ and Ca^{++} salts. Higher concentration of chloride is hazardous to human consumption and creates health problems. Desirable limit of chloride by **ISI (1991)** for drinking purpose is 250 mg/L.

In the present investigation, the Chloride concentration values varied. The values varied from 13.4 mg/L at station 1 to 30.62 mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 14.21 mg/L at station 1 to 31.54 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 16.80 mg/L at station 1 to 42.30 mg/L at station 16 (Table 4.3).

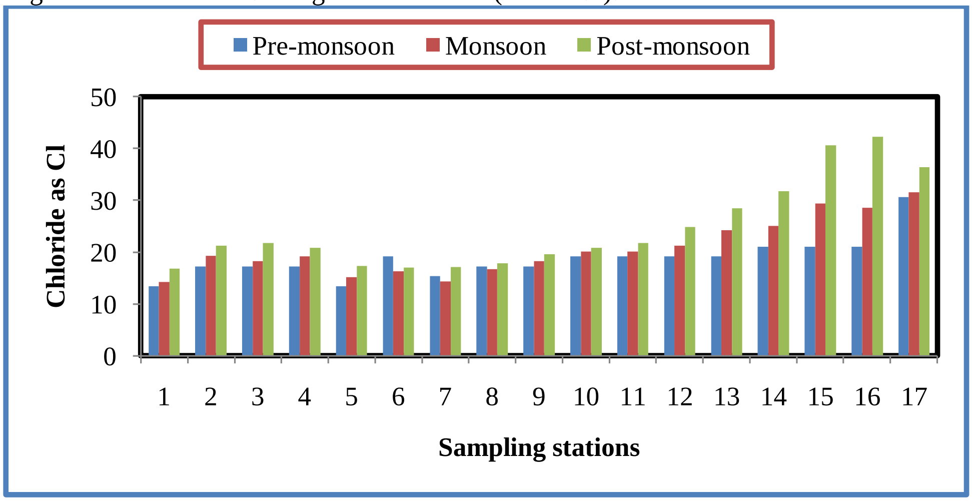

Figure 4.10: Seasonal variation of Total Hardness in Hemavathi River

4.2.7 Iron (Fe)

Fe is a potential source of color. Fe is known to contribute to light absorbance and water color in freshwaters and Fe and water color are often correlated across lakes (Canfield et al., 1984). Some studies indicate that complexes between Fe and OM affect water color more than OM alone (Pennanen and Frisk, 1984; Heikkinen, 1994; Maloney et al., 2005).

In the present investigation, the Iron concentration values varied. The values varied from BDL in almost all the sampling stations to 0.04 mg/L at station 6 in pre-monsoon season (Table 4.1). In monsoon season, the values were BDL (Table 4.2) and in post-monsoon season, it was BDL in all most all the sampling point (Table 4.3).

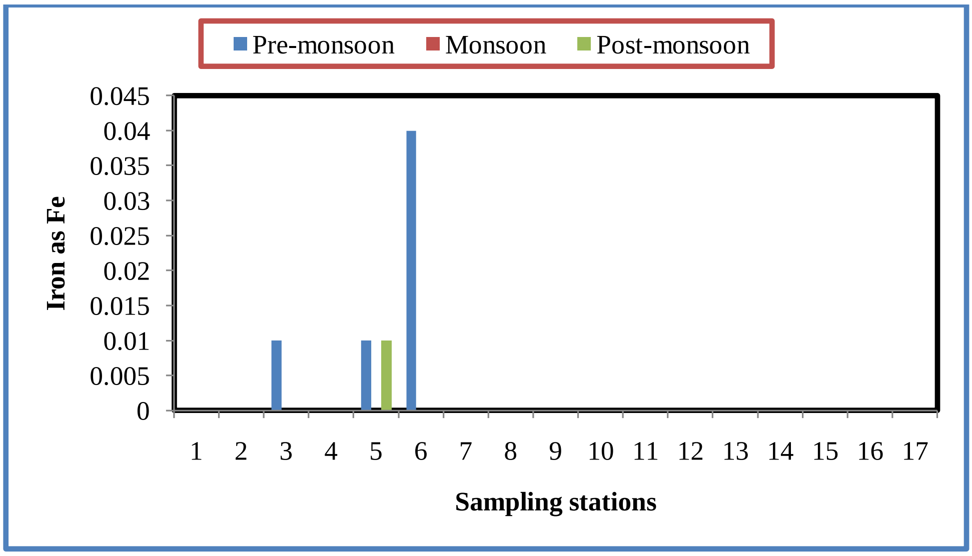

Figure 4.10: Seasonal variation of Total Hardness in Hemavathi River

4.2.8 Sodium (Na^+)

Sodium salts are highly soluble in water and hence all natural waters contain a little amount of sodium (**Roberts** and **Marsh, 1987**). It is found in the ionic form (Na^+) in plant and animal matter. It is an essential element for living organisms. Sodium and potassium are the two cations, which are needed as macronutrients for the growth of aquatic organisms.

In the present investigation, the sodium concentration values varied. The values varied from 3.6 mg/L at station 1 to 32.4 mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 4.1 mg/L at station 1 to 26.34 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 5.2 mg/L at station 1 to 45.2 mg/L at station 17 (Table 4.3).

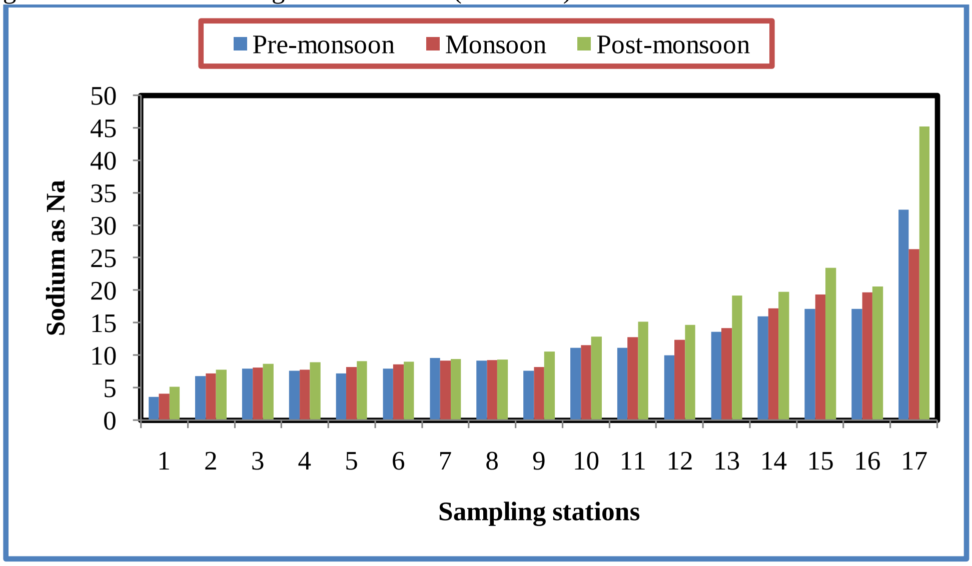

Figure 4.10: Seasonal variation of Total Hardness in Hemavathi River

4.2.9 Total Alkalinity (TA)

Alkalinity of water in general is the sum of all the alkaline components in the water system that act as buffer the water against changes in pH. The species composition of alkalinity depends on pH, mineral composition, water temperature and ionic strength. The alkalinity of neutral waters is due to the salts of weak acids and sometime may be strong bases. A reaction of carbon dioxide with calcium or magnesium carbonate in the soil creates considerable amounts of bicarbonates in the soil. Organic acids such as humic acid also form salts that increase alkalinity. Alkalinity itself has little public health significance, although highly alkaline waters are unpalatable and can cause gastrointestinal discomfort.

In the present investigation, the Alkalinity concentration values varied. The values varied from 11 mg/L at station 8 to 144.0 mg/L at station 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 22.0 mg/L at station 1 to 146.2 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from 26.0 mg/L at station 1 to 151.0 mg/L at station 17 (Table 4.3).

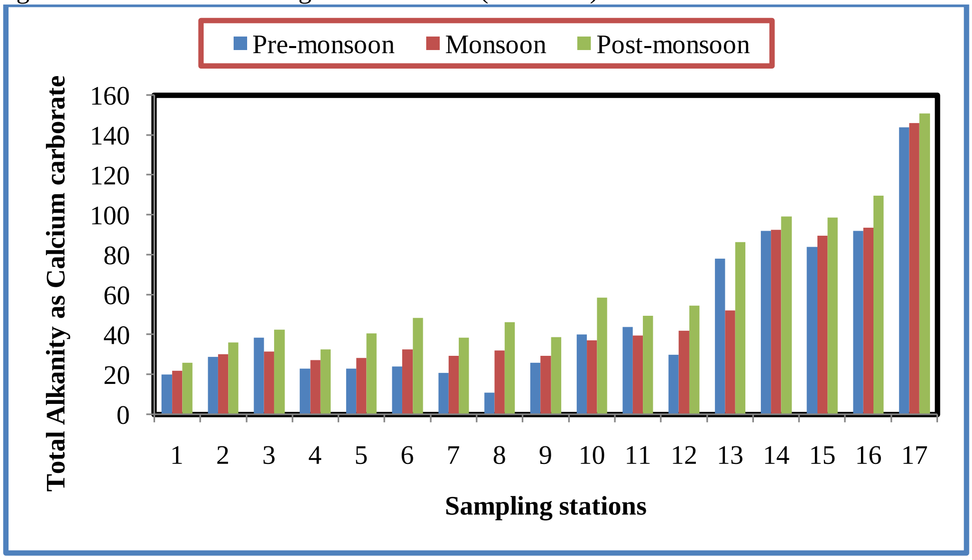

Figure 4.10: Seasonal variation of Total Hardness in Hemavathi River

4.3Biological water quality parameters

4.3.1Biological Oxygen Demand (BOD)

BOD is a measure of the amount of oxygen required for biological reactions taking place. Naturally, bacteria utilize organic matter in their respiration and remove oxygen from the water. BOD provides an estimate of how much biodegradable waste is present in the water. Biodegradable matter is usually composed of organic wastes, including leaves, grass clippings manure and pollutants.

In the present investigation, the BOD concentration values varied. The values were 0 in most of the sampling points and at station 16 the BOD value was 12 mg/L in pre-monsoon season (Table 4.1). In monsoon season, the values were zero in all the stations (Table 4.2) and in post-monsoon season, it ranged from BDL at most of the stations and a maximum of 6.80 was observed in station 16 mg/L at station 4 (Table 4.3).

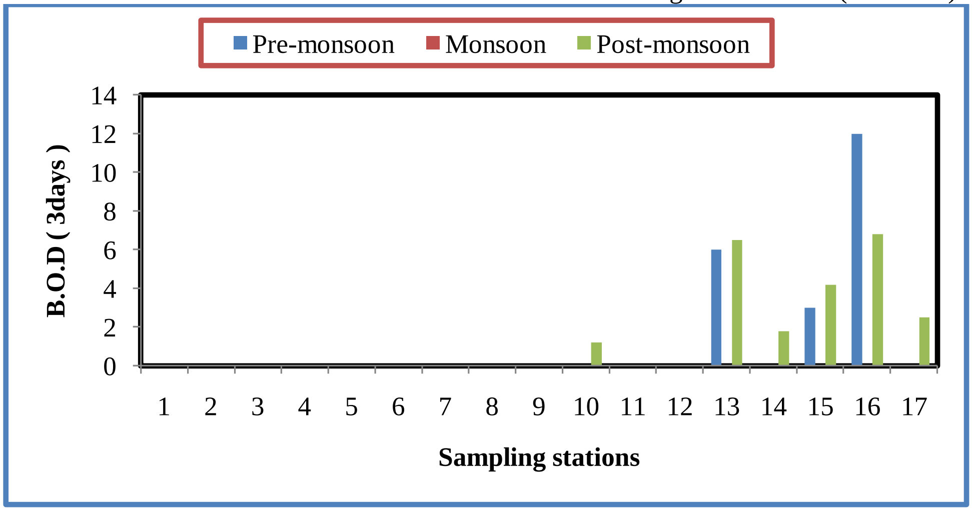

Figure 4.10: Seasonal variation of Total Hardness in Hemavathi River

4.3.2Dissolved Oxygen (DO)

Dissolved oxygen is essential for the self-purification process in natural water systems. The dissolved oxygen level may indicate the effects of oxidisable wastes on receiving waters. It also indicates the capacity of a natural body of water for maintaining aquatic life. The oxygen dissolved in water may be derived from the atmosphere or from the photosynthetic activity of aquatic plants. Many a times, the concentration of dissolved oxygen is depleted due to the pollution load and this renders the water unsuitable for consumption by living beings.

Depletion of DO in water is due to added materials would increase microbial activity (**Kataria *et al* 1996**). Pristine surface waters are normally saturated with DO but such DO can be rapidly removed by the oxygen demand generated out of decomposition of organic wastes and DO provides a broad indicator of water quality.

In the present investigation, the Dissolved oxygen concentration values varied. The values varied to maximum of from 7 mg/L at stations 6 and 11 to minimum of 4.8 mg/L at stations 15, 16 & 17 in pre-monsoon season (Table 4.1). In monsoon season, the values varied between 6.9 mg/L at stations 4 7 11 to 6.1 mg/L at station 17 (Table 4.2) and in post-monsoon season, it ranged from BDL at stations 7, 8 & 9 to 6.10 mg/L at station 4 (Table 4.3).

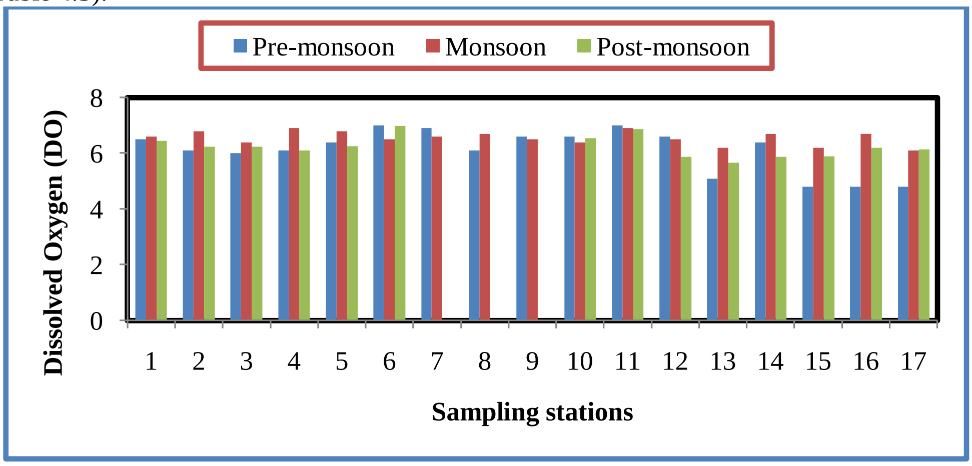

Figure 4.10: Seasonal variation of Total Hardness in Hemavathi River

4.4 Bacteriological Parameter

4.4.1 Total Coliforms (TC)

Elizabath and **Swapna (2005)**, in their study on Musi river, Hyderabad, **Harilal *et al* (2004)**, in their study on Karamana and Neyyer rivers of Kerala and **Chatterjee** and **Raziuddin (2001)**, in their study of Nunia river, found that all the samples contained total coliform bacteria above the safe limits for drinking water standards. Seasonal variations in bacterial density were recorded with maximum density in summer and monsoon seasons and minimum density in winter season. Similar observations were made during the study.

In the present investigation, the total Coli form values were 1 during all the seasons which indicates that the water is fit for drinking.

4.4.2Coliforms

Biological indicators of water quality are important since, they have the unique characteristics of survival and proliferation in water bodies. Under optimal conditions, even a single cell can grow in to millions in a short span of few hours and are more resistant than pathogens to the stresses of the aquatic environment and disinfection process (chlorination).In the present study the E-coli were absent in all the seasons.

4.4.3Pesticides

Anima upadhyay et. al., (2014) conducted a study on Hemavathi River during pre monsoon season. According to their study Alkalinity and calcium was a bit at higher side comparing to other physic chemicals parameters and their study concluded that the Hemavathi river water is fit for drinking and other activities. In the present study the pesticide concentrations was absent in all the seasons.

V. CONCLUSION

In the present study an attempt has been made to determine the major physical, chemical and bacteriological parameters of Hemavathi river by identifying 17 sampling stations. The following are conclusion drawn from the study,

- The water quality in the Hemavathi River is not seriously polluted. The outcome of the present study provides considerable information about the water quality status of the River. The results indicated that pH and DO were all within their natural background levels of 6.5–8.5 and 5.0–7.0, respectively. Nutrient loads in the River were mainly from domestic, agricultural and commercial activities. River is used for a variety of purposes such as drinking, fishing, irrigation and other domestic purposes without prior treatment.
- The present study provides simple representation of complex of variables (physical, biological and chemical) that govern the overall quality of surface water that are intended for potable use.
- River clearly showed that river water was safe for drinking water supply, fishery, irrigation and industrial purposes, as most of the parameters are found within the permissible limits.
- Pathogenic indicator organisms were absent in all the water samples render them fit for human consumption though they can be used for other purposes.

REFERENCES

[1] APHA, (1995). Standard methods for the examination of water and wastewater; 18th edition, AWWA, WPCF, New York, pp. 1120.

[2] APHA, (1998). Standard methods for the examinations of water and wastewater. 14th edition. New York.

[3] APHA, (2005). Standard methods for the examinations of water and wastewater. 21st edition. New York.

[4] Chatterjee Chinmoy and Raziuddin M. (2001). Bacteriological status of river water in Asansol town in West Bengal. *Journal Environmental Pollution*, Vol. 8, No.2, pp. 217-219.

[5] Elizabeth K. M. and Swapna C. (2005). Water pollution and bioremediation of some pollutants from river Musi, Hyderabad, Andhra Pradesh. *Ecology, Environment and Conservation*, Vol. 11, No. 2. pp. 273-6.

[6] Harilal C. C., Akness H. P. R. and Baji S. 2004. Hydrogeochemistry of two rivers of Kerala with special reference to drinking water quality. *Ecology Environment and Conservation.* Vol. 10, No. 2, pp. 187-192.

[7] Hem J. D. (1989). Study and interpretation of the Chemical Characterstics of natural water (3rd edition), US Geographical survey water supply paper, 2254, pp. 263.

[8] Indian Standards Institution (ISI). 1983. Indian standards specification for drinking water. IS-10500. New Delhi, India

[9] Kumar A. (2002). Ecology of Polluted Waters, 2 (1st edition), New Delhi: APH Publishing.

[10] Kataria H. C., Iqbal S. A. and Shandilya A. K. (1996). Limno-chemical studies of Tawa reservoir‖ *Indian Journal Environmental Proection.* Vol. 16, No. 11, pp. 841-846.
[11] Kotaiah B. and Kumarswamy N. (1994). Environmental engineering laboratory manual. Pradeep publications. Gujarat, pp. 49-51.
[12] Mishra S. R. and Saksena D. N. (1992). Aquatic Ecology. Ashish publishing house, New Delhi, India.
[13] Ramachandra T. V., Subash C. M. D., Gururaja K. V. and Sreekantha (2006). Cumulative Environmental Impact Assessment, Nova Science Publishers, Inc., New York
[14] Rao K. S., Karnath K. N., Gupta D. R., Shrivastava S., Usha C and Panday S. S. (1990). Studies on morphometric, hydrological and sedimental characteristics of Gandhisagar reservoir in relation to its fisheries.