

Water Quality Evaluation in Term of WQI River Tungabhadra, Karnataka, India.

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Abstract— The study reports the Weighted Arithmetic Water Quality Index (WQI_a) value obtained for River Tungabhadra, a major tributary of Krishna River basin. A WQI_a delivers a unique rating that gives whole water quality at a specific stretch and period depending upon some water quality constraints. The principle point of a WQI_a is to give complex water quality insights into data that is clear and useable by the community. Some of most critical water quality parameters such as pH, Total dissolved solids (TDS), Total alkalinity, dissolved oxygen (DO), Biochemical oxygen demand (BOD), Total hardness (TH), calcium (Ca), magnesium (Mg), and electrical conductivity (EC) were Used for evaluating the WQI_a. The WQI_a esteems for the Tungabhadra River oscillate from 40 to 156. The estimations of WQI_a exhibited that the stream water was free of any impurities at the examining sites aside from 2-3 months where its qualities were under good condition. On every occasion there are anthropogenic influence viz industrial effluent, agricultural runoff and domestic sewage which is directly discharge into stream water gets contaminated to some level and hence of WQI declines. It is opinioned that WQI_a can be used as a device in relating the water-quality of different sources. It delivers the community a over-all awareness of the thinkable glitches with water in a specific stretch. The WQI are among the best approaches to convey the data on water-quality pattern to the public community or to the water quality policy-makers and which is help full to drive suitable mitigative measure.

Rundown phrases— water-quality parameter, weighted arithmetic water quality index (WQI), Tungabhadra River.

I.INTRODUCTION

The Tungabhadra River is a familiar river in South India and is almost travels 531 km in distance. The Tungabhadra stream starts its ride from Koodli of Shivamoga district in the Karnataka state of India. The majority course of the stream flows in the state of Karnataka, India.

WQI_a is a rating system to delineate the general water-quality grade in a stretch that is useful for the choice of suitable treatment procedure to meet the concerned problems (Tyagi et al.2013). WQI is a tool to decide state of water quality of stream. Calculating the WQI contains three stages (US EPA 2009): (i) in that initial step which acquire measurements on separate water quality constraint, (ii) convert into “sub index” values (iii) finally total the individual sub index into general water quality index esteem.

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Series of mathematical equations mostly based on the mean methods like arithmetic, harmonic, logarithmic, mean multiplicative are widely adopted by various authors in developing water quality indices.

In 1965 R.K.Horton develop a water quality index based on aggregation arithmetic function by selecting ten most frequently parameter for WQI_a which include Biochemical oxygen demand (BOD),

dissolved oxygen (DO), pH, coliforms, Total suspended and Total dissolved Solids, Total alkalinity, and chloride. The aggregation of arithmetic considering of the water quality factor was replicated with the temperature and “evident contamination” to get the total capacity from which the general WQI_a was discovered. The arithmetic WQI_a weight fluctuated from one to four. Likewise, R.K. Horton.et.al. (1965), Despite the importance of multiplication factor in arithmetic weighting, R. M. Brown. et al. (1970) did not consider it rather used essential number arithmetic weighting National sanitation foundation (NSF) develop a water quality index based on Delphi technique which is expliained in Dalkey 1968, in that logarithmic function to adapt water quality factor consequences hooked on sub-index values.

According to S.H.Dinius in 1987 develop a WQI_m model based on mean multiplicative having decrease rating scale, with qualities communicated as a level of clean water quality relating to 100 %. Similar effort was attempted by Rescher and Helmer 1959, Helmer and Dalkey 1963 by presenting changes to Delphi method (Dalkey 1968). Brown et al. (1972), Bhargava et al. (1998), Dwivedi et al. (1997), Deininger and Landwehr (1976) provided multiplicative form of the index where weights to individual parameters were assigned based on a subjective opinion on the judgment and critical analysis of the author. N.Dee et al. (1973) anticipated a structure for assessing ecological factor effect of significant water-resources schemes.

McClelland (1974) developed a geometric function to estimate the WQI_g. He was of the opinion that the number arithmetic mean needed Affectability to low esteem parameters, a trademark later considered “covering”. He as an alternative proposed the “weighted geometric mean”. Procedure latter (Deininger and Landwehr 1976; Parker and Walski 1974; Bhargava et al.1983; S H Dinius 1987) have additionally utilized a weighted geometric mean for aggregation.

Dojlido et al. 1994 Utilize the harmonic mean to discover the WQI_h. This mean does not utilize weights for the individual parameter indicator. he is found that it was more

delicate to the most disabled marker than the number-crunching or symphonious methods, decreasing overshadowing, while as yet representing the impact of different pointers (Walsh and Wheeler 2012). **The either methods used** are “Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) and British Columbia water quality Index”. The “Canadian Council of Ministers of the Environment Water Quality Index” analyzes perceptions to a benchmark as opposed to normalizing watched qualities to abstract score curves, where the benchmark might be a water quality standard or site explicit foundation focus (CCME 2001; Khan et al. 2003; Lumb et al. 2006). “British Columbia water quality index” was created by the Canadian Ministry of Environment in 1995 as expanding file to assess water quality. This file is like CCME-WQI where water quality parameters are estimated and their infringement is controlled by examination with a predefined limit. It gives probability to make a characterization based on all current estimation parameters (Bharti and Katyal 2011).

Smith et al. (1987a, b) formulated an index based on optimized operator for four different class of water utilization i.e., point and non-point. It is a cross breed of the two regular index types and is depend on professional judgement as well as water-quality values. The selection of constraints for each water class, evolving sub-indices, and conveying weightages were all done using Delphi. The minimum operator technique was used to obtain the final index score (Bharti and Katyal 2011):

$$I_{\min} = \sum \text{Min} (I_{\text{sub}1}, I_{\text{sub}2}, \dots)$$

I_{\min} = the lowermost sub-index rate.

In over-all, WQI are parted into five steps (Sobhani 2003):

A) Community/public indices: this method assesses the water quality index neglects the application of water use for consumptions like drinking, irrigation, industrialization and aqua culture etc.,

B) Exact/specific consumption indices: aforementioned water uses application-based categorization of the water quality.

C) Statistical indices: indices are derived based on numerical/ statistical methods involving equations rather than the individual opinion.

D) Designing indices: decision support indices for preparation water quality managing the projects.

In this research work, the “weighted arithmetic mean”(WQI_a) technique is used.

$$WQI_a = \sum_{i=1}^n q_i * W_i$$

$W_i=1$ where W_i is the unit weight of each constraint, q_i = sub-index rating for each variable and n is the number of sub-indices aggregated.

The benefits of WQI_a method used in this study are (Tyagi et al. 2013).

1. This technique includes data from several water quality parameter into a scientific calculation that rates the healthiness of water body with number.

2. Data light assessment method meaning reduced number of variables requirement compared to all other water quality variables for specific use.

3. Useful method for assessment of water quality as it incorporates the weighted influence of the variables involved and assists decision makers in adopting appropriate strategies to cope with it

Replicates the compound effect of diverse variables i.e., significant for the valuation and managing of stream water quality.

II. MATERIAL AND METHODOLOGY

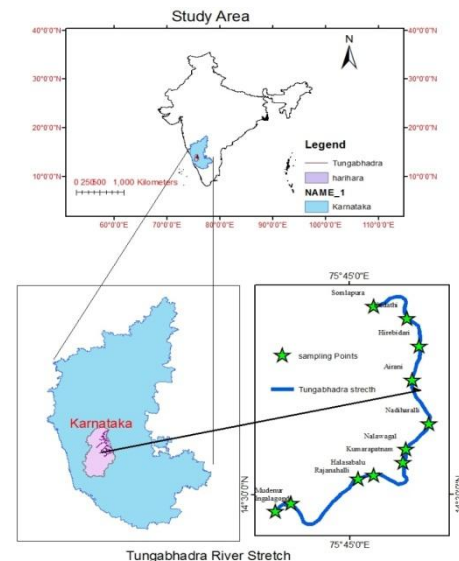


Fig.1 location of sampling station.

Stream water samples were Collected. from seven sampling-station viz. Mudenuuru (SS1), Rajanahalli (SS2), Kumarapatnam bridge (SS3), Nalawagal (SS4), Nadhiharalli (SS5), Airani (SS6) and Heribedri (SS7) during post-monsoon (POM), Pre-monsoon (PRM) and Monsoon (POM) season over a period of twelve month, i.e., from January 2018 to December 2018. The particulars of sampler station are shown in Fig. 1.

Several physico-chemical and biological constraints of the water samples were examined by following the typical organizations of APHA (2005). A set of ten most regularly used water quality parameters namely Electrical conductivity (EC), Total dissolved solid (TDS), Total suspended solid (TSS), pH, Total alkalinity (TA), Total hardness (TH), Chloride, Dissolved oxygen (DO), Biochemical oxygen demand (BOD) and sulphate which, organized, reflect the complete water quality of the Tungabhadra River were chosen for producing the WQI_a was eastimated by following the “weighted arithmetic index method” (Brown et al. 1970), using the condition:

$$WQI = \sum Q_n W_n / \sum W_n$$

Where

Q_n = quality rating is designed using the condition $Q_n = 100[(V_n - V_i)/(V_s - V_i)]$

V_n = actual amount of n th parameter present, V_i is the ideal value of the parameter [$V_i=0$, except for pH ($V_i=7$)]

and DO ($V_i=14.6$ mg/l), V_s is the standard permissible value for the n th water quality parameter Unit weight (W_n) is calculated using the formula

$W_n=k/V_s$ where k = proportionality constant i.e., $k=[1/\sum 1/V_s=1, 2, \dots, n]$ (Brown et al. 1970).

III. RESULTS AND DISCUSSION

For ascertaining Water quality index, the prime pre-essential is the consequences of different water quality parameter analysis. The numerical summary of the chose water quality parameters at various sampling station of the Tungabhadra River all over Pre-monsoon, Monsoon and Post monsoon season is displayed in Table 2.

Table 1 water quality range and possible usage of water sample (brown et al. 1970)

WQI	Water quality status	Possible usage
0.0-25.0	Excellent.	Drinking, irrigation and industrial.
26.0-50.0	Good.	Drinking, irrigation and industrial.
51.0-75.0	Poor.	Irrigation and industrial.
76.0-100.0	very poor.	Irrigation.
>100.0	unsuitable for drinking and aqua culture.	Proper treatment required before use.

Table 2. Range of value for water quality parameter of Tungabhadra river.

Parameter	Pre-monsoon	Monsoon	Post-monsoon
Ph	7.46±0.607 (6.7-8.25)	7.49±0.476 (6.8-8.2)	7.5±0.50 (6.85-7.85)
EC	350.3±74.2 (221-440)	222.23±36.9 (155-240)	218±34.99 (185.5-285.5)
TDS	328.55±97.96 (182-440)	129.7±20.3 (91-140)	137.5±25.92 (116.5-195.5)
TSS	190.42±120.262 (60-385)	222.15±131.52 (75-375)	190.428±120 (62-185.5)
TH	134.42±29.27 (79.5-160.33)	72.2±10.37 (56.3-83.5)	96.25±41.2 (67-120.2)
chloride	45.23±7.7 (32.2-52.33)	29.8±7.3 (18.5-39.5)	31.9±2.98 (27.2-34.5)
DO	6.8±1.2 (5.1-8.4)	8.12±1.02 (6.3-9.1)	7.36±0.86 (6.01-8.2)
BOD	4.77±2.57 (2.2-6.84)	3.96±1.75 (2.05-5.3)	3.59±2.136 (2.4-8.1)
sulphate	11.14±4.23 (4.65-15)	9.85±5.64 (4.68-20.58)	6.8±0.76 (5.32-7.85)
TA	142.23±29.5 (81.34-164)	96.83±22.11 (64.8-112)	96.302±35.3 (60-170)

Values expressed in mean with standard deviation (range bound)

pH for the most part implies the level of acidity or alkalinity of a water. The normal pH esteems for pre-monsoon, monsoon and post-monsoon season were 7.45 ± 0.60 , 7.42 ± 0.40 and 7.52 ± 0.5 , respectively. Even with the fact that the normal pH range were within the BIS recommendation, in this case, sampling station 5 i.e Nalavagalu village having High pH around 8.3. Electrical conductivity dealings the electric current passing/carrying capacity of a river sample and which is linked to the total dissolved ions present in the stream water. Experiential Electrical conductivity values for the water sample of the Tungabhadra River fluctuated between 350.3 ± 74.216 μ mho/cm, 222.3 ± 36.914 μ mho/cm and 218 ± 35 μ mho/cm over period Pre-monsoon, Monsoon and Post-monsoon season respectively, during Pre-monsoon season EC value exceed the BIS standard of 300 μ mho/cm at some of the sampling station.

Table no.3 relative weight W_n parameter used in WQI_a.

Parameter	BIS Standard	Unit weight W_n
pH	6.5-8.5	0.215
Electrical Conductivity	300	0.0061
TDS	500	0.00366
TSS	500	0.00366
Total Hardness	300	0.0061
chloride	250	0.00732
DO	5	0.366
BOD	5	0.366
sulphate	150	0.0122
Total Alkalinity	120	0.01525
$\sum W_n$		1.00129

Table no .4 Values of water quality index at Sampling station 1.

	Pre-Monsoon			Monsoon			Post-Monsoon		
Parameter	V _n	Q _n	Q _n W _n	V _n	Q _n	Q _n W _n	V _n	Q _n	Q _n W _n
pH	7.05	10	2.15	7.1	20	4.3	6.9	-20	-4.3
EC	221.52	73.84	0.450424	155.2	51.73333	0.315573	187.9	62.63333	0.382063
TDS	128.48	25.696	0.094047	91.58	18.316	0.067037	116.48	23.296	0.085263
TSS	60	12	0.04392	75	15	0.0549	80	16	0.05856
TH	79.45	26.48333	0.161548	56.9	18.96667	0.115697	67.7	22.56667	0.137657
chloride	32.82	13.128	0.096097	18.48	7.392	0.054109	27.26	10.904	0.079817
DO	8.4	64.58333	23.6375	9.1	57.29167	20.96875	7.59	73.02083	26.72563
BOD	2.6	52	19.032	2.05	41	15.006	2.44	48.8	17.8608
sulphate	6.896	4.597333	0.056087	4.78	3.186667	0.038877	5.32	3.546667	0.043269
TA	135.4	112.8333	1.720708	64.68	53.9	0.821975	72.38	60.31667	0.919829
	$\sum WQI$			$\sum WQI$			$\sum WQI$		
	WQI			WQI			WQI		
	47.44233			41.74292			41.99288		
	47.38121			41.68914			41.93878		

Table no .5 Values of water quality index at Sampling station 2.

	Pre-Monsoon			Monsoon			Post-Monsoon		
Parameter	V _n	Q _n	Q _n *W _n	V _n	Q _n	Q _n *W _n	V _n	Q _n	Q _n *W _n
pH	7.14	28	6.02	7.4	80	17.2	7.75	150	32.25
EC	298.74	99.58	0.607438	205.33	68.44333	0.417504	195.5	65.16667	0.397517
TDS	182.74	36.548	0.133766	147.58	29.516	0.108029	128.48	25.696	0.094047
TSS	125	25	0.0915	215	43	0.15738	320	64	0.23424
TH	113.5	37.83333	0.230783	73.4	24.46667	0.149247	83.2	27.73333	0.169173
chloride	37.9858	15.19432	0.111222	23.28	9.312	0.068164	32.82	13.128	0.096097
DO	7.68	72.08333	26.3825	8.9	59.375	21.73125	8.2	66.66667	24.4
BOD	6.84	136.8	50.0688	3.8	76	27.816	4.5	90	32.94
sulphate	9.64	6.426667	0.078405	6.84	4.56	0.055632	6.896	4.597333	0.056087
TA	138.45	115.375	1.759469	102.34	85.28333	1.300571	89.5	74.58333	1.137396
	$\sum WQI$			$\sum WQI$			$\sum WQI$		
	WQI			WQI			WQI		
	85.37375			68.91488			91.65632		

TDS and TSS are to measure of total dissolved and suspended elements existing in a water and both

parameters must be within BIS standard limit of 500 mg/l. Dissolved and suspended solid are contain both inorganic as well as organic in nature. The absorption of TDS for the stream water samples ranged from 182.74 to 448 mg/l during Pre-monsoon, from 91.58 to 152 mg/l during Monsoon and from 116.48 to 132.5 mg/l during Post-monsoon season, which were well within the BIS desirable limit of 500 mg/l. Similarly, TSS values were also within the desirable limit with mean values of 190.42 ± 120.266 mg/l, 222.69 ± 131.52 mg/l and 278.76 ± 106.88 mg/l during Pre-monsoon, Monsoon and Post-monsoon season, respectively...

Total Hardness (TH) can observed from the lather creating capacity of a stream water in that calcium and magnesium cations are mainly control the hardness. The experimental values of TH for the water samples of the Tungabhadra River during premonsoon, monsoon and post-

monsoon season ranged from 134.6 ± 29.73 mg/l, 72.3 ± 10.2 mg/l and 96 ± 41.23 mg/l one-to-one, and the values were within the BIS limit of 300 mg/l. Grounded on the hardness values, Tungabhadra River water normally falls just below moderately hard to hard water group.

Chloride is one of the significant water quality constraint and is extensively circulated in landscape in the form of salts of potassium chloride (KCl), calcium chloride (CaCl_2) and sodium chloride (NaCl). Various sources contributing chloride in water are draining from different rocks by the way toward enduring, surface run-off from inorganic manures subordinate horticultural fields, water system release, creature nourishes, and so forth. Tungabhadra river which contain chloride during Pre-monsoon, Monsoon and Post-monsoon season were $45.23 (\pm 7.7)$ mg/l, $29.8 (\pm 7.3)$ mg/l and $31.9 (\pm 2.98)$ mg/l, separately. In present-study the chloride, value are within under BIS desirable limit, i.e., 250 mg/l.

Table no .6 value of water quality index at Sampling station 3.

Parameter	Pre-Monsoon			Monsoon			Post-Monsoon		
	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn
pH	6.7	-60	-12.9	6.8	-40	-8.6	6.85	-30	-6.45
EC	351.39	117.13	0.714493	260.52	86.84	0.529724	185.5	61.83333	0.377183
TDS	86.48	17.296	0.063303	152.38	30.476	0.111542	128.48	25.696	0.094047
TSS	121	24.2	0.088572	325	65	0.2379	325	65	0.2379
TH	142.89	47.63	0.290543	82.35	27.45	0.167445	72.5	24.16667	0.147417
chloride	45.355	18.142	0.132799	26.54	10.616	0.077709	28.5	11.4	0.083448
DO	6.5	84.375	30.88125	8.1	67.70833	24.78125	7.95	69.27083	25.35313
BOD	3.5	70	25.62	2.7	54	19.764	2.6	52	19.032
sulphate	12.09	8.06	0.098332	14.6	9.733333	0.118747	6.896	4.597333	0.056087
TA	158.84	132.3667	2.018592	120	100	1.525	89.6	74.66667	1.138667
		Σ WQI	47.00788		Σ WQI	38.71332		Σ WQI	40.06987
		WQI	46.94732		WQI	38.66344		WQI	40.01825

Table no .7 values of water quality index at Sampling station 4.

Parameter	Pre-Monsoon			Monsoon			Post-Monsoon		
	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn
pH	8.12	224	48.16	7.65	130	27.95	7.85	170	36.55
EC	334.82	111.6067	0.680801	221.52	73.84	0.450424	220	73.33333	0.447333
TDS	182.74	36.548	0.133766	128.48	25.696	0.094047	195	39	0.14274
TSS	195	39	0.14274	85	17	0.06222	360	72	0.26352
TH	133.96	44.65333	0.272385	79.45	26.48333	0.161548	80.5	26.83333	0.163683
chloride	43.85	17.54	0.128393	32.82	13.128	0.096097	33.8	13.52	0.098966
DO	5.8	91.66667	33.55	7.9	69.79167	25.54375	6.3	86.45833	31.64375
BOD	2.84	56.8	20.7888	5.53	110.6	40.4796	3	60	21.96
sulphate	4.65	3.1	0.03782	7.18	4.786667	0.058397	7.1	4.733333	0.057747
TA	81.34	67.78333	1.033696	112.34	93.61667	1.427654	81.34	67.78333	1.033696
		Σ WQI	104.9284		Σ WQI	96.32374		Σ WQI	92.36144
		WQI	104.7932		WQI	96.19964		WQI	92.24244

Table no .8 values of water quality index at Sampling station 5.

Parameter	Pre-Monsoon			Monsoon			Post-Monsoon		
	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn
pH	8.25	250	53.75	8.235	247	53.105	7.85	170	36.55
EC	408.15	136.05	0.829905	268.13	89.37667	0.545198	285.6	95.2	0.58072
TDS	247.89	49.578	0.181455	128.48	25.696	0.094047	133.5	26.7	0.097722
TSS	385	77	0.28182	120	24	0.08784	326	65.2	0.238632
TH	154.36	51.45333	0.313865	68.43	22.81	0.139141	180	60	0.366
chloride	50.12	20.048	0.146751	39.5	15.8	0.115656	32.82	13.128	0.096097
DO	5.1	98.95833	36.21875	6.32	86.25	31.5675	6.01	89.47917	32.74938
BOD	8.6	172	62.952	6.1	122	44.652	8.1	162	59.292
sulphate	15.6	10.4	0.12688	8.12	5.413333	0.066043	6.6	4.4	0.05368
TA	164.12	136.7667	2.085692	119.35	99.45833	1.51674	81.34	67.78333	1.033696
		Σ WQI	156.8871		Σ WQI	131.8892		Σ WQI	131.0579
		WQI	156.685		WQI	131.7192		WQI	130.8891

Table no .9 values of water quality index at Sampling station 6.

Parameter	Pre-Monsoon			Monsoon			Post-Monsoon		
	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn
pH	7.88	176	37.84	7.65	130	27.95	8.2	240	51.6
EC	397.78	132.5933	0.808819	240.35	80.11667	0.488712	235.6	78.53333	0.479053
TDS	62.15	12.43	0.045494	140	28	0.10248	132	26.4	0.096624
TSS	122	24.4	0.089304	365	73	0.26718	360	72	0.26352
TH	160.33	53.44333	0.326004	61.5	20.5	0.12505	120.5	40.16667	0.245017
chloride	52.75	21.1	0.154452	34.5	13.8	0.101016	35.7	14.28	0.10453
DO	6.5	84.375	30.88125	7.5	73.95833	27.06875	7.1	78.125	28.59375
BOD	6.8	136	49.776	5.4	108	39.528	2.5	50	18.3
sulphate	15.26	10.17333	0.124115	20.6	13.73333	0.167547	6.896	4.597333	0.056087
TA	162.1	135.0833	2.060021	78.1	65.08333	0.992521	81.34	67.78333	1.033696
		Σ WQI	122.1055		Σ WQI	96.79126		Σ WQI	100.7723
		WQI	121.9481		WQI	96.66656		WQI	100.6424

Table no .10 values of water quality index at Sampling station 7.

Parameter	Pre-Monsoon			Monsoon			Post-Monsoon		
	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn	Vn	Qn	Qn*Wn
pH	7.1	20	4.3	7.1	20	4.3	7.15	30	6.45
EC	439.86	146.62	0.894382	212	70.66667	0.431067	218	72.66667	0.443267
TDS	254.72	50.944	0.186455	120	24	0.08784	128.48	25.696	0.094047
TSS	325	65	0.2379	370	74	0.27084	180	36	0.13176
TH	157.77	52.59	0.320799	83.4	27.8	0.16958	68.5	22.83333	0.139283
chloride	53.78	21.512	0.157468	33.5	13.4	0.098088	32.82	13.128	0.096097
DO	8.1	67.70833	24.78125	9.1	57.29167	20.96875	8.05	68.22917	24.97188
BOD	2.2	44	16.104	2.15	43	15.738	2.05	41	15.006
sulphate	13.87	9.246667	0.112809	6.896	4.597333	0.056087	7.85	5.233333	0.063847
TA	159.6	133	2.02825	81.34	67.78333	1.033696	169.5	141.25	2.154063
		Σ WQI	49.12331		Σ WQI	43.15395		Σ WQI	49.55024
		WQI	49.06003		WQI	43.09835		WQI	49.4864

Chloride is one of the significant water quality constraint and is extensively circulated in landscape in the form of salts of potassium chloride (KCl), calcium chloride (CaCl_2) and sodium chloride (NaCl). Various sources contributing chloride in water are draining from different rocks by the way toward enduring, surface run-off from inorganic manures subordinate horticultural fields, water system release, creature nourishes, and so forth. Tungabhadra river which contain chloride during Pre-monsoon, Monsoon and Post-monsoon season were $45.23 (\pm 7.7)$ mg/l, $29.8 (\pm 7.3)$ mg/l and $31.9 (\pm 2.98)$ mg/l, separately. In present-study the chloride, value are within under BIS desirable limit, i.e., 250 mg/l.

Total amount of oxygen dissolved in a water body is named as dissolved oxygen (DO) and its absorption depend on physical turbulence, chemical mixing and biological actions of the water body. Assessment of dissolved oxygen is very much important to mitigate from contamination. A dissolved oxygen concentration level of 4– 6 mg/l is the range for a ideal water quality supporting aquatic life. DO level which comes under this ideal range is relied upon to be contaminated. The mean DO values ranged from a 6.384 ± 1.2 mg/l during pre-monsoon season, maximum DO observe in monsoon of 8.1322 mg/l (± 1.02). DO is minimum (<4 mg/l) at site S5 during Pre-monsoon, due to high industrial waste discharged directly into river stretch directly.

Over-all volume of dissolved oxygen essential by “aerobic microorganisms” for complete ruin of organic wastes existing in a water body is labelled as biochemical oxygen demand (BOD). Therefore, BOD is a pointer of natural contamination with higher number demonstrating

more elevated amounts of natural contamination (Patel et al. 1983). BOD values specifically over 5 mg/l are objectionable and the present examination discovered the mean BOD as 4.78 (± 2.57) mg/l, 3.96 (± 1.7) mg/l and 3.6 (± 1.136) mg/l amid pre-monsoon, monsoon and post-monsoon season, respectively. The higher estimations of BOD underscored the nearness of conspicuous natural contamination source close to the sampling station.

Presence of sulphate in stream water is for the most part normal in nature contributed essentially by mineral sources like gypsum, and so on. Despite the fact that in little fixation sulphate is innocuous, in any case, high convergence of sulphate in drinking water may cause different intestinal infections. Mean sulphate convergence of the water tests under scrutiny fluctuated from 11.134 mg/l (± 4.23) amid pre-monsoon season to 6.8 mg/l (± 0.76) during post-monsoon season and the qualities were within the desirable limits of 150 mg/l according to BIS.

Total alkalinity is the ability of an aqueous solution to defuse an acid. Alkalinity is formed because of the different bicarbonate, carbonate and hydroxide particles present in water. The average absorption of alkalinity present in water samples was observed to be 142.85(± 29.5) mg/l, 96.83 (± 22.2) mg/l and 92.8(± 35.3) mg/l during pre-monsoon, monsoon and post monsoon season, respectively. The mean alkalinity

WQI_a Analysis: The initial step in calculation of WQI_a using "weighted arithmetic index" method is the assessment of unit weight of each physico-chemical constraints well thought-out for the investigation. The unit weight assigning process is done to transform the constraints of different scale to a common scale. As an example, unit weights and the drinking quality standards assigned to each constraint for WQI_a is shown in Table 3. Higher the weights assigned higher is their significance in calculating WQI_a. Maximum unit weight, i.e., 36.6% is allocated to both BOD and DO, along these lines proposing the key essentialness of these couple constraints in water quality evaluation and their significant effect on the WQI_a. Tables 4 to 10 experiential values of the all the physico-chemical parameters (10 parameters are selected) and their WQI_a from all the inspecting sites for three seasons under consideration. Of all the selected parameters DO and BOD had significant influence on the WQI_a values as presented in tables 4 to 10.

Table 11 summarizes the WQI_a values from all stretch for each season. Most of the samples sandwiched between good to unsuitable water category ($41 < \text{WQI} < 157$). Pre-monsoon season recorded highest WQI_a values ranging between 41.7 at site SS6 to 156.7 at site SS5 with an average WQI value of 112.47 ± 30.02 (Table 11). Direct discharge from nearby urban residents and industries resulted in the poor river quality further exacerbated by low flow in the pre-monsoon season.

Yamakanamardi and Sebastian (2013) reported similar results for the Cauvery River. Current research revealed that the most polluted sites are SS4, SS5 and site SS6 based on the WQI_a values along the entire reach of the Tungabhadra River. The WQI value of site SS5 indicate that the water quality is unfit for use be it; drinking, aquaculture, recreation or irrigation (Table 1). Rehana and Mujumdar (2011) in their paper also presented the analogous water

quality for Tunga-Bhadra River. In the same way, inspecting site SS4, i.e., Nalavagalu and kumarapatanam town, the overpopulated municipal cluster laterally Tungabhadra River also observed a extremely degraded water quality primarily contributed by massive demographic over and above socio-economic burden in the form of stream bed infringement and stream water misuse for numerous chores.

The, site SS5 held very poor to notfit water quality status as indicated by the WQI values of 156.7 during post-monsoon season and 131.89 during monsoon season (Table no.11). In this manner, sampling station SS5 imprisoned extremely poor to unfit water quality trend as demonstrated by the WQI_a estimations of 156.7 in the period of post-rainy season and 131.89 amid rainy season (Table no.11). Correspondingly, the poor water quality at sampling sites SS4, SS5 and SS6 is the consequence of direct discharge of sewage from adjoining urban settlements viz. Nalawagalu town, Nadiharahali and Airani, respectively.

Table no .11 Summary of water quality index of Tungabhadra stream.

	pre-monsoon		monsoon		post monsoon	
	WQI	WQS	WQI	WQS	WQI	WQS
ss1	47.4	Good	41.68	Good	41.943	Good
ss2	85.38	Poor	68.91	Poor	91.66	Poor
ss3	46.94	Good	38.6	Good	40.01	Good
ss4	104.8	very	96.19	very	92.243	very
ss5	156.7	poor	131	poor	130	poor
ss6	121.94		96.66		100.64	
ss7	49.06	Good	43.09	Good	49.5	Good

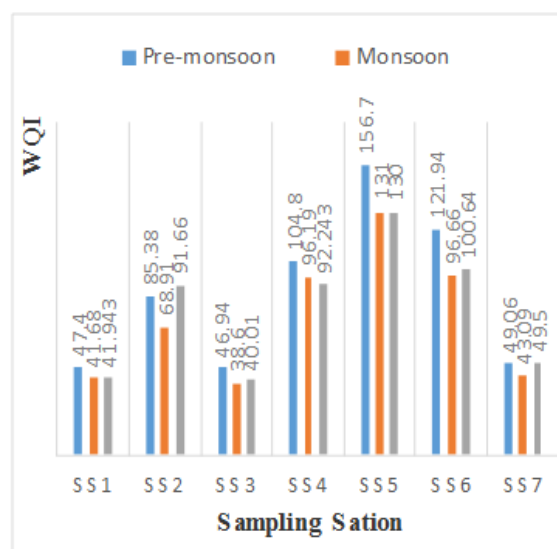


Fig.2 Water quality index rating of various sampling sites of Tungabhadra river

The poor water quality at these sites as indicated by WQI_a values can be traced back to the anthropogenic activities such as leaking/ improperly managed sanitation facilities, direct sewage discharge and solid waste dumping, industrial discharge, etc. from Tables 4 to 10 clearly signifies BOD

and DO were the most influencing parameters in WQI_a design. High organic pollution load contributed to high BOD concentration lowering the DO concentration along the stretch of Tungabhadra river as portrayed by water samples. The WQI_a at sampling station SS6, i.e., close Airani, a rural area, was relatively good in comparison to all the deliberate locations with values wavering from 100 during winter days to 96.5 during rainy period. Moving further downstream along the stretch site SS7 hosted comparatively enhanced water quality owing to the dilution of pollution, microbial degradation of the organic load and scanty residents along the river. The pollution levels indicated seasonal change in water quality that is improved water quality during monsoon compared to pre and post monsoon (fig 2). As seen in Figure 2 there is a gradual decrease in pollution level moving downstream from SS5 to SS7. The trough in the graph at station 3 indicate the remote location of the site without much anthropogenic influence. However, contrasting high pollution load in station SS2 and SS4 can be related to demographic as well as industrial raw wastewater discharge. In all season, the water qualities were found to be good for the stations s1, SS3, and SS7 herein after referred as fit-sites while poor to unsuitable at site SS2, SS4, S5 and SS6 herein after referred as unfit-sites as depicted in Fig.2. During pre-monsoon season and post-monsoon, water quality of the sampling sites was found to fall under unsuitable to poor water quality attributable to the low flow in the river and the direct discharge of organic load at the unfit-sites. In contrast to this, the monsoon season showed improvement in water quality for all sampling stations indicating the dilution of pollutants through increased waterflow. Despite the increased flow during monsoon, the WQI_a score at site SS2, SS4, SS5 and SS6 showed unsuitable water quality rating throughout year for the reason that of the flow is insufficient to increased organic pollution load, thus reducing the self-purification capacity of the river at these sites.

VI. CONCLUSION

WQI_a stands out to be a very useful approach in valuation and management of water quality. This study is first of its kind undertaken on the Tungabhadra river stretch in Karnataka. provides valuable vision into the status of overall relevance of a studied-on Tungabhadra river stretch constructed on WQI_a values. It also provides a profounder thoughtful of communication of many physico-chemical constraints upon the over-all water-quality of a Tungabhadra river. The seasonal variation in the water quality of the Tungabhadra river based on the on the analysis of water samples from seven different sampling stations was carried out in this study. The study has both academic value and practical significance. Based on experiential WQI_a values it can be determined that powerful action measures are immediately required to recover the Tungabhadra river water quality. It also suggests immediate need for appropriate water quality management plan that addresses any impending strategy for justifiable stream rebuilding. Appropriate measures could take up towards restriction of discharge of raw industrial and sewerage from residential/commercial establishments, storm-water channel into the stream and avoiding unabated throwing away of

solid waste by societies living along the stream side. Furthermore, desilting actions to recover the conveying capacity of the stream channel needs to be adopted. Any activities of development involving encroachment of river should be strictly prohibited along the river corridor.

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