RESEARCH PAPER:

Seasonal water quality status in Tungbhadra river around TB dam, Karnataka, India

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SUMMARY

It is important to make an assessment of quality for the best use of water resources distribution and utilization. It becomes necessary to have an idea of the present and future demand of water for various use *e.g.* irrigation, industries, public health and river conservation. In the present study, water quality analysis of Tungabhadra River around Tungabhadra Dam, from Kudli (upstream) to Honnarahalli (downstream) has been carried out in order to determine the sources responsible for deterioration of water quality. In order to evaluate the quality of Tungabhadra River, water samples were collected from different locations in various seasons during 2009-10. Analyses were carried out with various chemical techniques to determine the water quality. The water quality parameters were analyzed; pH, electrical conductivity, total dissolved solid (TDS), dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total hardness, total alkalinity, chloride, Nitrate, sulphate, sodium and potassium. Ten different stations were selected in the present study along the river basin for the sample collection. The study identified increase in the anthropogenic activities which is the main source of pollution. It was observed that the main cause of deterioration in water quality was due to the lack of proper sanitation, unprotected river sites. The river water cannot be used for domestic purposes without any form of treatment.

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Human activities involve the use of water in one way or the other. It may be noted that man's early habitation and civilization sprang up along the banks of rivers. However, with the rapid increase in the population of the country and the need to meet the increasing demands of irrigation, human and industrial consumption, the available water resources in many parts of the country are getting depleted and the water quality has been deteriorated. Indian rivers are polluted due to the discharge of untreated sewage and industrial effluents (Bhardwaj, 2005). The situation is no different in the Tungabhadra river basin, where agricultural activities, urbanization and industrialization have significant impacts on water quality. In this context, the study would help to meet the continued need for sound information on the situation analysis, extent of water-quality problems, variations in water quality in different seasons, on understanding other key issues and constraints.

Generally, the seasonal variability for many constituents is weaker in the downstream when compared with the upstream of the reservoirs. This is beneficial for downstream users because the result is more reliable and there is consistent quality of the water supply. There are several reports on river water quality assessment using physico–chemical and biological parameters (Madhyastha *et al.,* 1999; Sinha *et al.,* 2004; Singh and Gupta 2004 and Santosh *et al.,* 2007.

The population pressures in the basin cause an acceleration of the progressive deterioration of water quality because of increased domestic, municipal, agricultural and industrial activities and effluent being discharged into water bodies and increase in environmental degradation.

In the present study, water quality analysis of Tungabhadra River around Tungabhadra Dam, from Kudli (upstream) to Honnarahalli (downstream) has been carried out in order to determine the sources responsible for deterioration of water quality.

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Tungabhadra dam is located across Tungabhadra River in Bellarty District, Karnataka State, India. Similar to other resources, this river is also under environmental stress due to siltation, human encroachment, high macrophytic population and sewage input from various sources. There are number of drains discharging loads of sewage, domestic waste water and industrial effluents directly into the river. This dam has influence of various anthropogenic activities and rapid pace of industrialization in the catchment areas upstream. In this manner, the river has received silt containing fertilizers, insecticides, pesticides which are used for agriculture upstream. The main objective of this study is to evaluate the water quality problems of upstream and downstream, variations in water quality in different seasons of Tungabhadra River.

MATERIALS AND METHODS

Tunga and Bhadra rises near Samse in the Aroli hill range of Kudremukh, lies between latitude 13^0 15' 70'' N and longitude 75^0 09' 42'' E, Karnataka State, India. Bhadra river initially flows east, changing course to north and joins Tunga at Kudli in Shimoga District. The study area is situated at elevation about 550 meters above mean sea level (MSL) and lies between latitude 14^0 2'36.28"N to $15^0$45'33.69"N and longitude $75^0$41'39.25"E to $76^0$56'35.11"E. In the present study area the main human activities are included as agriculture, several industries and other domestic activities.

River Tungabhadra is the largest tributary of the river Krishna, contributing an annual discharge of 14,700 million m^3 at its confluence point to the main river. The river is transboundary and flows about 531 kms from its origin in Karnataka state, before it joins river Krishna at Sanghameshwaram near Kurnool in the neighbouring state of Andhra Pradesh. The Tungabhadra sub basin (TBSB) stretches over an area of 48,827 sq. km in both the riparian states of Karnataka (38,790 sq. km) and Andhra Pradesh (9037 sq. km) and finally joins Krishna that flows into Bay of Bengal.

Water samples were collected in different seasons of 2009–10 for the physico-chemical analysis. Ten samples were collected from different locations of study area which are shown in Fig. 1 and Table 1. Water samples were collected in three different seasons at each location as per standard method of sampling techniques, APHA, (1998). Some of the sensitive parameters such as temperature, pH and electrical conductivity were determined directly in the field and DO was preserved for the subsequent laboratory analyses like electrical conductivity, pH, turbidity, BOD, total alkalinity, TDS, nitrate, and sulphate. These were analyzed within 24 hours and subsequently total hardness, calcium, magnesium, sodium, potassium, were analyzed. The water analyses were carried out as per the methods described by Trivedy and Goel (1986), APHA (1998) and Hooda and Kaur (1999).

RESULTS AND DISCUSSION

The results are summarized in Tables 2 and 5. All parameters are based on changeable water quality, like anthropogenic activities and natural phenomena. Therefore, DO and BOD were determined to check the

Table1: Sampling, locations in Tungabhadra river

Station no.	Sample locations	Longitude E	Latitude N	Alt (MSL)	Source of contamination
L_1	Vaishnavahalli, Tunga River	$75^0$38'40.37"E	$13^0$58'26.46"N	564	Agricultural activities, Sand mining
L_2	Bhadra River, Hole Honnur	$75^0$40'32.61"E	$13^0$59'43.75"N	566	Domestic sewage
L_3	S. Kodamaggi, Tungabhadra River	$75^0$41'39.25"E	14^0 2'36.28"N	555	Sand mining, agricultural activities
L_4	DS, Honnali	$75^0$38'35.45"E	$14^0$15'58.28"N	541	Domestic sewage
L_5	Sarathi	$75^0$49'12.25"E	$14^0$34'30.97"N	528	Industries, bathing, washing clothes, sand mining, agricultural activities
L_6	Mylara	$75^0$40'53.28"E	$14^0$47'50.93"N	516	Floating population for temple, bathing, washing clothes, sand mining, agricultural activities
L_7	Madalagatti	$75^0$53'20.79"E	15^0 6'39.42"N	502	Industries, bathing, washing clothes, sand mining, agricultural activities
L_8	TB Dam	$76^0$19'31.02"E	$15^0$16'7.86"N	492	
L_9	Shanapur	$76^0$38'49.54"E	$15^0$26'33.96"N	395	Industries, bathing, washing clothes, sand mining, agricultural activities
L_{10}	Honnarahalli	$76^0$56'35.11"E	$15^0$45'33.69"N	366	Industries, bathing, washing clothes, sand mining, agricultural activities

Table 2: Results of physico-chemical analysis in Tungabhadra river

	Post Monsoon 2009				Winter 2010				Summer 2010			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
pH	7.1	7.6	7.33	0.18	7.1	7.7	7.38	0.18	7.5	7.9	7.74	0.13
Ec	68	983	290.5	264.29	151	769	301.2	185.53	159	1010	374.4	260.48
TDS	42	634	187.5	170.59	87	469	187.5	115.53	104	637	239	161.56
COD	53	106	83.6	16.61	54	93	71.6	11.39	58	80	67.2	7.00
Total alkanity	70	264	115	55.12	56	222	99.2	50.93	50	162	89	39.25
Total hardness	140	298	193.6	53.08	124	270	166.4	45.61	270	440	334	60.04
Chlorides	8	148	48.4	51.94	4	120	37	35.15	28	166	60	41.68
Sulphates	128.4	291.2	172.2	44.84	22	186	61.9	47.18	20	192	62.6	51.16
Flourides	0.42	2.24	0.871	0.54	0.2	0.5	0.36	0.11	0.1	2	0.43	0.56
Sodium	23.4	137.6	80.73	45.19	4	85	27.5	26.49	6	94	25.7	26.14
Potassium	0.3	8.8	2.8	3.19	1	8	3.98	2.83	1	16	4.2	4.57
DO	6.2	6.8	6.5	0.18	6.2	6.9	6.52	0.23	6.2	6.7	6.47	0.16
BOD	2.6	5.4	3.89	0.90	3.5	5.4	4.34	0.66	2.2	3.5	2.85	0.50
Nitrates	0.26	2.84	0.89	0.82	0.34	2.34	0.907	0.62	0.78	3.45	1.389	0.78

organic and inorganic pollution in water. pH ranged from a minimum of 7.1 at Honnali (L4) in post-monsoon, to a maximum 7.9 at TB dam (L8)in summer (Table 1). Higher pH always favours the fish production in reservoir. As per the WHO (1998) 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. The pH observed in the present study is similar with Kataria *et al.* (1996). The seasonal variations of pH in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are shown in Fig. 2a.

Electrical conductivity (EC) is used as a basic index to select the suitability of water for agricultural purposes. Kataria *et al.* (1996) noted electrical conductivity which ranged from 151-227 µmhos/cm in "Hathaikheda Dam" water and 320-18860 µmhos/cm in Betwa River. Generally, the conductivity of a river is lowest at the source of its catchments and as it flows along the course of the river, it leaches ions from the soils and also picks up organic materials from biota and its detritus (Ferrar, 1989).

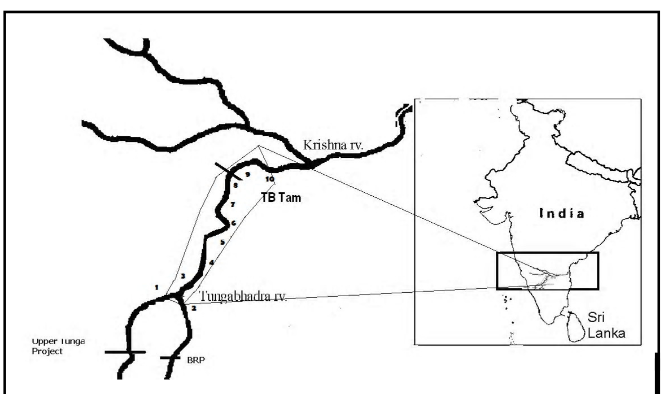

Fig. 1: Map of the study area, Tungabhadra river

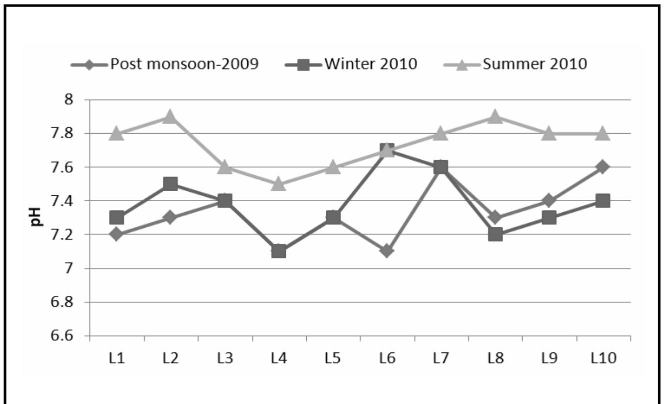

Fig. 2a: Variations of pH

The average value of unpolluted rivers is approximately 350ìmhos/cm (Koning and Roos, 1999). In the present study EC was minimum, 68 µmhos/cm at Vaishnavahalli (L_1) and maximum, (1010 µmhos/cm) at Honnarahalli (L_{10}) during summer. The seasonal variations of EC in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2b.

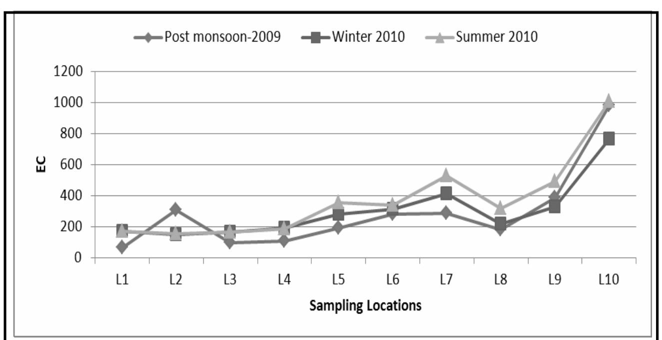

Fig. 2b: Variations of EC

Total dissolved solids (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 study TDS ranged from minimum of 42 mg/L at Vaishnavahalli (L_1) to a maximum of 634 mg/L in Honnarahalli (L_{10}) during post-monsoon; and the minimum of 87 mg/L at L_2, to a maximum 469 mg/L at L_{10} and the minimum of 104 mg/L at L_2, to a maximum 637 mg/L at L_{10} station in summer. The seasonal variations of TDS in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2c.

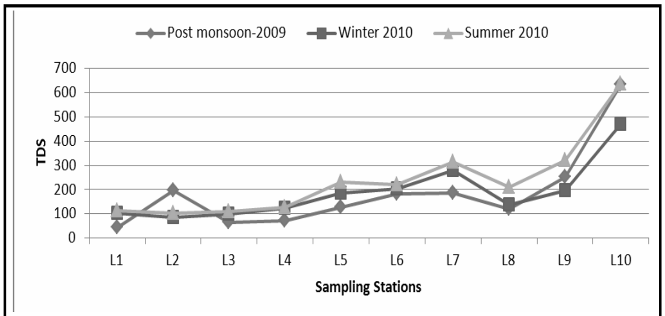

Fig. 2c: Variations of TDS

Total hardness (T++) is determined as $CaCO_3$ mg/L. Mainly TH causes from cations of calcium, magnesium, iron and strontium. In the present study, minimum of 140 mg/L at L_3 station to a maximum of 298 mg/L at L_{10} during post-monsoon; the minimum of 124 mg/L at L_1, to a maximum 270 mg/L at L_{10} stations during winter, and the minimum of 270 mg/L at L_1 to a maximum 440 mg/L at L_{10} station in summer (Table 2). The seasonal variations of Total hardness in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig.2d.

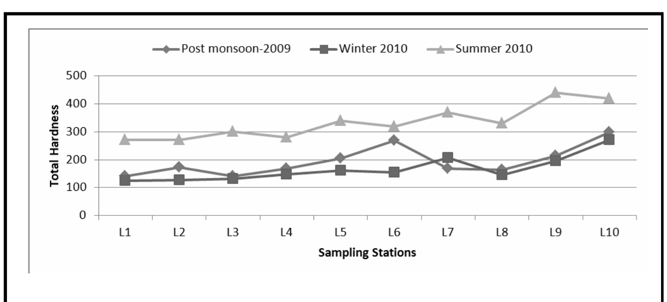

Fig. 2d: Variations of total hardness

Total alkalinity in natural water is generally imparted by the hydrolysis of salts such as carbonates, bicarbonates, phosphates and nitrates. Lower values of alkalinity indicate that anions and cations are not concentrated. Higher values of alkalinity causes problem like inscrutability in water pipelines. Alkalinity in this study ranged from 70-264 mg/L which was attributed to bicarbonate. The seasonal variations of total alkalinity in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2e.

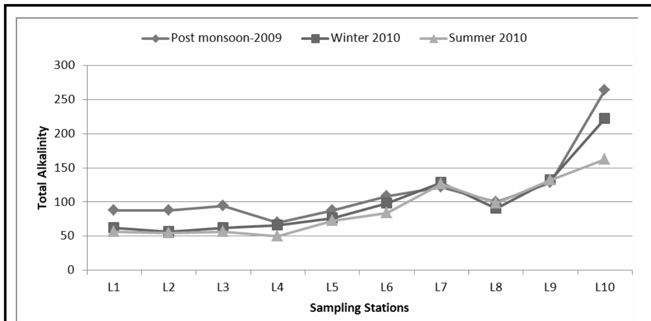

Fig. 2e: Variations of total alkalinity

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 study it varied from 8 mg/L at L_1 station to a maximum of 148 mg/L in L_{10} during post-monsoon, the minimum of 4 mg/L at L_1, to a maximum 120 mg/L at L_{10} stations during winter and the minimum of 28 mg/L at L_1 to a maximum 166 mg/L at L_{10} station in summer (Table 2). All samples were under permissible as compared with WHO standards. The seasonal variations of chloride in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2f.

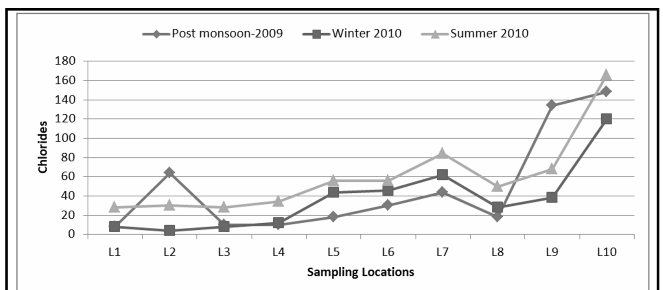

Fig. 2f: Variations of chlorides

Dissolved oxygen (DO) test measures the amount of life-sustaining oxygen dissolved in the water. This oxygen is available for fish, invertebrates, and all other aquatic animals. Most aquatic plants and animals need oxygen to survive. Depletion of DO in water is due to high temperature or 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 of organic wastes, and the management of DO provides a broad indicator of water quality (DFID, 1999). DO concentrations in unpolluted water are normally about 8–10 mg/L at 25^0 C (DFID, 1999). Sedimentation of suspended solids can cause build up of decomposing organic matter in sediments and dissolved NH_3 can contribute oxygen depletion due to nitrification. Low level of dissolved oxygen is a sign of possible pollution. Therefore DO is one of the water quality indices. In the present study, it varied from 6.2 mg/L at L_3 station to a maximum of 6.8mg/L at L_{10} during post-monsoon; and the minimum of 6.2mg/L at L_9, to a maximum 6.9 mg/L at L_5 station during winter, and the minimum of 6.2mg/L at L_6 to a maximum 6.7mg/L at L_7 station in summer. The seasonal variations of Dissolved Oxygen in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2g.

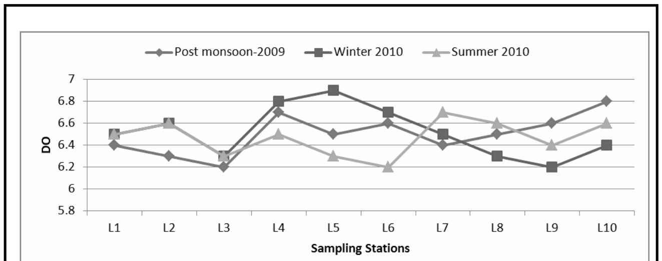

Fig. 2g: Variations of DOs

Biochemical oxygen demand (BOD) is a measure of the amount of biological pollutions. Naturally, bacteria utilize organic matter in their respiration and remove oxygen from the water. The BOD test 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. Here, BOD varied from 2.6 mg/L at L_6 station to a maximum of 5.4 mg/L in L_7 during post-monsoon; and the minimum of 3.5 mg/L at L_6 station to a maximum 5.4 mg/L at L_9 during winter, and the minimum of 2.2 mg/L at L_2 to a maximum 3.5 mg/L at L_5 station in summer. The seasonal variations of Biochemical oxygen demand in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2h.

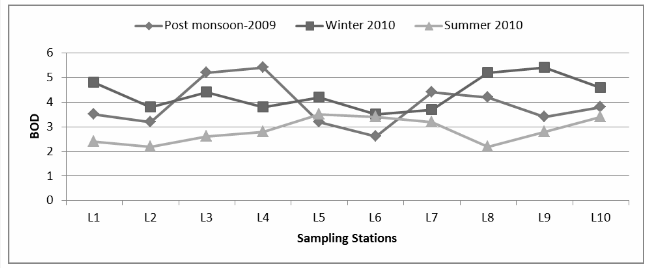

Fig. 2h: Variations of BOD

Nitrate is added by common sources such as fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris. Water naturally contains less than 1 milligram of nitrate-nitrogen per litre and is not a major source of exposure. Higher levels indicate that the water has been contaminated. In the present study, nitrate ranged from a minimum of 0.26 mg/L at L_1 station to a maximum of 2.86 mg/L at L_{10} during post-monsoon; and the minimum of 0.34 mg/L at L2, to a maximum of 2.34 mg/L at L_{10} stations during winter, and the minimum of 0.78 mg/L at L_1 to a maximum of 3.45 mg/L at L_{10} station in summer. This indicated that the water samples had permissible levels of nitrates when compared with the WHO standards having a standard value >45mg/L. The seasonal variations of nitrates in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2i.

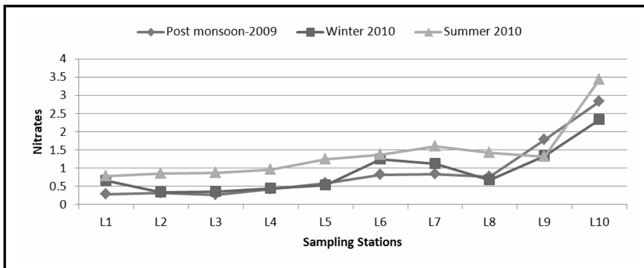

Fig. 2i: Variations of nitrates

Sulphates (SO_4) were analysed in the water samples which indicated that, it was present in the range of 20-291.2 mg/L. Water samples collected from Honnarahalli (L_{10}) was found to have high levels of SO_4 which is attributable to washing clothes, animals and bathing activities in the river. The seasonal variations of Sulphates in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2j.

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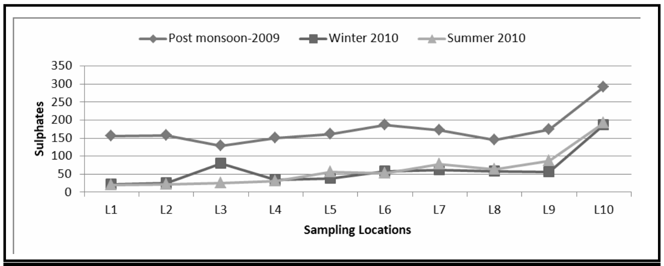

Fig. 2j: Variations of sulphates

The concentration of Fluorides in surface water samples ranged from 0.1 to 2.4 mg/L, which when further compared with the standard value of 1.0 mg/L, clearly showed that the surface water samples of TB dam, downstream of TB dam, namely Shanapur (L_9) and Honnarahalli (L_{10}) were high in fluoride concentration. The seasonal variations of fluorides in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra River are given in Fig. 2k.

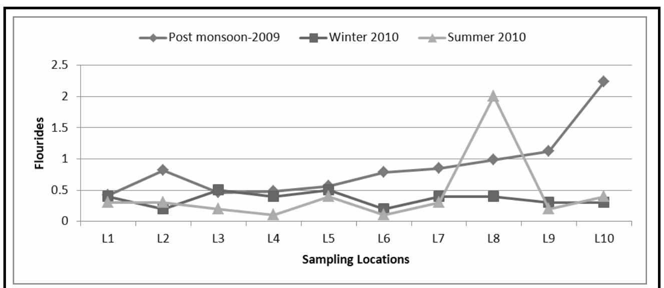

Fig. 2k: Variations of fluorides

Sodium (Na) and Potassium (K) were analyzed and found to be within the permissible levels. Values obtained from the present study ranged from 4-137 mg/L and 0.3-16 mg/L, for sodium (Na) and potassium (K), respectively. The seasonal variations of sodium (Na) and potassium (K) in 10 stations during 2009-10 at TB Dam, upstream and downstream of Tungabhadra river are given in Fig. 2l and 2m, respectively.

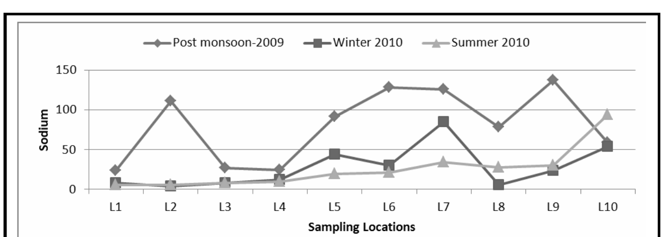

Fig. 2l: Variations of sodium

Conclusion:

The present study provides simple representation complex of variables (physical, biological and chemical) that govern the overall quality of surface water that are

Table 3: Physico chemical analysis in Tungabhadra river during post monsoon 2009

Station No.	pH	EC	TDS	COD	Total alkalinity	Total hardness	Ca	Mg	Chlorides	Sulphates	Flourides	Sodium	Potassium	DO	BOD	Nitrates
L_1	7.2	68	42	68	88	140	48	92	8	155.4	0.42	23.4	0.7	6.4	3.5	0.28
L_2	7.3	307	195	74	88	172	100	72	64	156.8	0.82	111	3.7	6.3	3.2	0.32
L_3	7.4	101	65	102	94	140	30	110	10	128.4	0.46	27.3	0.3	6.2	5.2	0.26
L_4	7.1	109	70	106	70	168	50	118	10	151	0.48	24.3	0.3	6.7	5.4	0.42
L_5	7.3	194	126	76	88	204	54	150	18	161.2	0.56	91.5	0.8	6.5	3.2	0.58
L_6	7.1	282	183	53	108	268	76	92	30	187	0.78	128.4	1.8	6.6	2.6	0.82
L_7	7.6	290	186	98	122	168	110	58	44	171.8	0.85	125.9	2	6.4	4.4	0.84
L_8	7.3	183	121	93	100	164	58	106	18	145.6	0.98	78.9	1.3	6.5	4.2	0.76
L_9	7.4	388	253	80	128	214	170	44	134	173.6	1.12	137.6	8.8	6.6	3.4	1.78
L_{10}	7.6	983	634	86	264	298	182	116	148	291.2	2.24	59	8.3	6.8	3.8	2.84

Table 4 : Physico chemical analysis in Tungabhadra river during winter 2010

Station No.	pH	EC	TDS	COD	Total alkalinity	Total hardness	Ca	Mg	Chlorides	Sulphates	Flourides	Sodium	Potassium	DO	BOD	Nitrates
L_1	7.3	172	101	80	62	124	17.6	19.4	8	22	0.4	8	1	6.5	4.8	0.66
L_2	7.5	151	87	67	56	126	17.6	19.9	4	26	0.2	4	1	6.6	3.8	0.34
L_3	7.4	166	98	72	62	132	25.6	16.5	8	80	0.5	8	1.2	6.3	4.4	0.36
L_4	7.1	191	122	64	66	148	20.8	23	12	34	0.4	12	1.5	6.8	3.8	0.45
L_5	7.3	283	186	76	76	162	28.8	21	44	38	0.5	44	6	6.9	4.2	0.54
L_6	7.7	317	202	66	98	154	24.8	22	46	57	0.2	30	6	6.7	3.5	1.24
L_7	7.6	415	278	62	128	206	31.2	31	62	62	0.4	85	5	6.5	3.7	1.12
L_8	7.2	218	137	54	90	146	26.4	19.4	28	58	0.4	6	2.5	6.3	5.2	0.68
L_9	7.3	330	195	93	132	196	36.8	25	38	56	0.3	24	7.6	6.2	5.4	1.34
L_{10}	7.4	769	469	82	222	270	53.6	33	120	186	0.3	54	8	6.4	4.6	2.34

Table 5: Physico chemical analysis in Tungabhadra river during summer 2010

Station No.	pH	EC	TDS	COD	Total alkalinity	Total hardness	Ca	Mg	Chlorides	Sulphates	Flourides	Sodium	Potassium	DO	BOD	Nitrates
L_1	7.8	174	113	74	56	270	90	180	28	20	0.3	6	1	6.5	2.4	0.78
L_2	7.9	159	104	70	54	270	100	170	30	22	0.3	6	1	6.6	2.2	0.86
L_3	7.6	167	111	68	56	300	90	210	28	26	0.2	8	1	6.3	2.6	0.88
L_4	7.5	190	128	60	50	280	110	170	34	30	0.1	10	2	6.5	2.8	0.96
L_5	7.6	357	230	64	72	340	100	240	56	56	0.4	20	2	6.3	3.5	1.24
L_6	7.7	342	220	60	84	320	80	240	56	52	0.1	21	3	6.2	3.4	1.38
L_7	7.8	530	316	66	126	370	100	270	84	78	0.3	34	6	6.7	3.2	1.6
L_8	7.9	320	211	58	98	330	70	260	50	64	2	28	4	6.6	2.2	1.42
L_9	7.8	495	320	72	132	440	180	260	68	86	0.2	30	6	6.4	2.8	1.32
L_{10}	7.8	1010	637	80	162	420	190	230	166	192	0.4	94	16	6.6	3.4	3.45

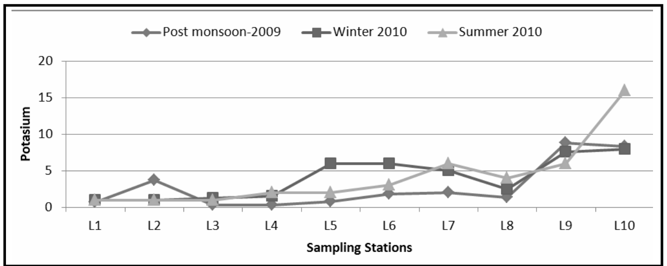

Fig. 2m: Variations of potassium

intended for potable use. It indicates that during post monsoon few of the water quality parameters like nitrate (in upstream), EC, total hardness, BOD and TDS (in downstream) were more which is due to release of agricultural runoff, domestic waste water and industrial effluent into the river.

Industrial sector is one of the major sources of water pollution across the basin. There are 27 large-scale industries and 2,543 small-scale industries in the river basin. Mysore Paper Mills (MPM) and Vishweshvaraiah Iron and Steel Industries (VSIL) are the two major industries on the bank of Bhadra river. Harihara Polyfibres, GRASIM, two sugar industries and two distilleries are the major industries located across Tungabhadra river. The total water consumption for industries in the basin is 6.1 TMC in the basin (4.56 TMC from Tungabhadra and 1.54 from Bhadra river). Water is non-alkaline and it is suitable for water pipe line. Total hardness was higher than alkalinity. The above data on the water quality parameters of Tungabhadra river clearly showed that river water was safe for drinking water supply, fishery, irrigation, and industrial purposes, as most of the parameters were found within the permissible limits. However, it is advisable to treat the water before it is supplied for potable purpose.

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