Hydro-chemical Characteristics of Mandakini River at Chitrakoot

Water quality of river Mandakini was assessed from Sati Anusuya to Karwi. Altogether 4 samples were collected from each sampling station and 5 sampling stations were selected for analysis. The quality analysis was made through the estimation of temperature, turbidity, DO, pH, EC, TDS, sodium, potassium, calcium, magnesium, carbonate, bicarbonate, chloride, sulphate, nitrate and phoshpate. The water quality of river Mandakini get degraded with respect to some of the analyzed parameters as it proceeds towards Karwi. Calcium and magnesium are dominating cations (accounting for about 65 to 75 % of the total cations) and bicarbonate and carbonate anions (accounting for about 75 to 89 % of total anions) were found dominating in river water.

INTRODUCTION

River Mandakini, called Paisuni in Government recods, originates in Kelhauna hills about 20 km west of Majhgawan town (a block and tahsil headquater) in Satna district. In the upper reach, the river is essentially seasonal. During non-monsoon season, the river becomes almost dry in this reach. It is only at the sacred spot of Sati Anusuya Ashram that a number of springs from the nearby lime stone hillocks feed the river and convert it into a perennial stream. Afterwards, it meanders through various sizes of hillocks and finally joins river Yamuna near Rajapur. Chitrakoot essentially comprises of some 20 villages collectively called Chitrakoot Dham. The area lies on the border of Madhya Pradesh and Uttar Pradesh. River Mandakini meanders through these villages and serves as the life line of the area. Chitrakoot area has great historical, mythological and religious significance. It is believed to have sheltered Lord Ram for a long period during his exile. Hence, river Mandakini is piously called 'Ganga Ji' and is worshipped everyday. A dip in a holy river is believed to wash away all sins. Being obsessed by such faith, people bathe in this river, especially on some auspicious occasions, such as Deepawali, Somwati Amawasya, Purnima and Amavasyas, etc.

Study area

The river Mandakini originates near village Kalhaura in the Majhgawn block, district Satna of Madhya Pradesh at latitude 24°52'N and longitude 80°41'E. The river flows generally in a south to north direction, through in the first and last reaches a west to east trend is also significant. The river flows in Madhya Pradesh for about 25 km, then makes a border of district Satna (Madhya Pradesh) and district Chitrakoot (Uttar Pradesh) for the next 25 km and again enters in Madhya Pradesh just down stream of Sati Anusuya. After flowing through about 15 km more in M.P., it crosses into Uttar Pradesh near Ramghat in Chitrakoot area and later flows only in Uttar Praddsh finally it joins river Yamuna near Rajapur.

MATERIAL AND METHOD

Sampling by random selection was done. The samples were identical to that of the parent water body. The water samples (around 3 L in volume) were collected from the each station and investigation was done for summer, post-monsoon and winter season. The physico-chemical parameters determined by standard method (APHA, 1989). The various analyzed parameters include temperature, turbidity, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total alkalinity (TA), total hardness, carbonate, biocarbonate, chlorides, sulphate, nitrate, phosphates, sodium, potassium, calcium and magnesium.

RESULT AND DISCUSSION

Result is tabulated in tables 1 to 3. Water quality parameters, like DO and chloride were always found in desirable limit at every site. The turbidity in the river Mandakini was found higher then the recommended value of World Health Organization (WHO, 1996).

Table 1. *Water quality of parameters of river Mandakini during summer, 2000 (Average values), in mg/L*

Parameter	Sati Anus-uya	Sphatik Sh-ila	Jankikund	Ramghat	Karwi
Turbidity, NTU	6.5	7.5	7.25	6.25	8.75
pH	7.02	7.7	7.8	8.0	8.12
Electrical coneuctivity, μmhos/cm	443.0	445.0	459.25	455.25	413.75
Total hardness	247.0	240.5	238.0	240.75	227.75
Total alkalinity	199.25	180.25	202.0	199.25	196.0
TDS	248.25	319.5	327.0	329.0	294.25
DO	10.07	10.57	10.07	9.7	10.87
Phosphate	0.17	0.16	0.17	0.18	0.18
Biocarbonate	129.25	117.5	128.2	128.37	124.92
Carbonate	48.0	40.5	48.75	50.8	51.2
Sulphate	4.65	5.47	8.37	11.12	13.62
Nitrate	0.61	0.76	0.75	0.90	0.87
Chloride	12.57	12.85	14.0	16.0	17.67
Calcium	47.9	42.0	41.12	41.35	39.3
Magnesium	30.62	32.5	32.45	32.9	31.0
Sodium	15.37	16.37	16.37	17.37	17.7
Potassium	10.4	10.45	10.37	11.37	11.97

Table 2. *Water quality parameters of river Mandakini during post-monsoon, 2000 (Average values), in mg/L*

Parameter	Sati Anusuya	Sphatik Shila	Jankikund	Ramghat	Karwi
Turbidity, NTU	8.5	8.75	8.5	9.5	11.5
pH	7.72	8.17	8.02	7.9	8.2
Electrical conductivity, μmhos/cm	449.0	450.0	463.0	462.25	414.25
Total hardness	256.0	259.95	261.75	271.0	264.75
Total alkalinity	200.5	203.5	205.8	201.67	200.35
TDS	328.25	344.75	341.2	346.0	344.0
DO	8.17	10.7	10.6	9.9	10.15
Phosphate	0.15	0.15	0.14	0.15	0.15
Biocarbonate	132.0	131.5	133.52	135.17	128.02
Carbonate	48.25	49.0	43.72	45.15	50.92
Sulphate	5.9	6.87	9.95	12.67	15.02
Nitrate	0.65	0.66	0.73	0.86	0.87
Chloride	12.57	13.8	15.5	17.87	19.2
Calcium	49.6	50.57	42.22	43.87	48.2
Magnesium	31.75	31.9	37.4	38.6	36.8
Sodium	16.35	16.85	17.35	18.47	18.4
Potassium	10.67	10.85	10.75	12.0	12.45

EC of river was found between the range of 358 - 466 μmhos/cm, showed that the river water quality is good. On the basis of Sawyer's classification (Sawyer, 1989) of hardness, the water quality obtained from different sites were found hard. Calcium, magnesium concentration, total alkalinity, bicarbonate and carbonate concentration were recorded relatively higher at Sati Anusuya and Jankikund. It had showed declining trend towards down stream during all the season, due to excessive $CaCO_3$ precipitation.

Phosphates, nitrates and sulphates were rather low at all locations. Increasing trend was observed while proceeding down stream Sodium content in river water varied from 14.9 to 18.47 mg/L. The potassium content was also low (10.3 to 12.45 mg/L) at all the studied locations. Bicarbonate concentrations varied from 117.5 to 133.5 mg/L and carbonate concentration in river water found between 40.0 to 52.87 mg/L. Percentage composition of the major

Table 3. *Water quality parameters of river Mandakini during winter, 2000 (Average values), In mg/L*

Parameter	Sati Anusuya	Sphatik Shila	Jankikund	Ramghat	Karwi
Temperature, ^0C	23.52	23.35	23.57	23.0	23.2
Turbidity, NTU	7.75	8.5	8.75	7.25	10.75
pH	7.45	8.12	8.0	7.7	8.17
Electrical conductivity, µmhos/cm	442.75	444.75	457.8	452.0	415.75
Total hardness	248.75	245.5	239.75	241.25	225.5
Total alkalinity	182.0	195.5	205.2	189.0	193.2
TDS	315.5	315.5	330.8	326.75	290.75
DO	8.5	9.67	9.05	9.1	10.1
Phosphate	0.13	0.13	0.14	0.15	0.15
Bicarbonate	128.25	128.4	126.8	126.8	126.25
Carbonate	28.25	46.61	52.9	43.7	48.7
Sulphate	4.5	5.9	8.8	11.7	14.3
Nitrate	0.5	0.65	0.7	0.84	0.8
Chloride	12.3	12.9	15.3	16.5	18.2
Calcium	49.3	42.85	42.1	40.9	39.1
Magnesium	30.1	33.2	23.25	33.35	30.6
Sodium	14.9	16.5	16.8	17.4	17.6
Potassium	10.42	10.3	10.9	11.35	11.75

Table 4. *Major ions concentrations in river Mandakini water of Sati Anusuya*

Sati Anusuya	Summer			Post-monsoon			Winter		
major ions	mg/L	m.eq/L	%	mg/L	m.eq/L	%	mg/L	m.ed/L	%
HCO_3^-	129.25	2.1	88.2	132.0	2.16	87.6	128.25	2.1	88.4
SO_4^{2-}	4.65	0.09	3.17	5.9	0.12	3.9	4.5	0.09	3.2
Cl^-	12.57	0.35	8.7	12.57	0.35	8.5	12.27	0.34	8.4
Ca^{2+}	47.9	2.39	46.0	49.6	2.48	45.7	49.3	2.46	47.0
Mg^{2+}	30.6	2.5	29.3	31.75	2.6	29.2	30.1	2.5	28.8
Na^+	15.37	0.66	14.8	16.35	0.71	15.1	14.9	0.64	14.3
K^+	10.4	0.26	9.9	10.67	0.27	10.0	10.42	0.26	9.9

Table 5 *Major ions concentrations in river Mandakini water of Sphatikshila*

Sphatik Shila	Summer			Post-monsoon			Winter		
major ions	mg/L	m.eq/L	%	mg/L	m.eq/L	%	mg/L	m.eq/L	%
HCO_3^-	117.5	1.92	86.5	131.5	2.15	86.4	128.4	2.1	87.2
SO_4^{2-}	5.8	0.11	4.1	6.9	0.14	4.5	5.9	0.12	4.1
Cl^-	12.85	0.36	9.4	13.8	0.40	9.1	12.9	0.36	8.7
Ca^{2+}	42.0	2.1	41.4	50.6	2.52	45.9	43.85	2.14	41.6
Mg^{2+}	32.5	2.7	32.1	31.9	2.66	28.9	33.8	2.76	32.6
Na^+	16.4	3.71	16.2	16.85	0.73	15.3	16.52	0.71	16.1
K^+	10.45	0.26	10.3	10.85	0.27	9.8	10.3	0.26	10.1

ions (cations: Calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+) and anions : Biocarbonate (HCO_3^-), carbonate (CO_3^{2-}), sulphate (SO_4^{2-}) and chloride (Cl^-) have been shown in tables 4 to 8. Standards are given in table 9. Percentage composition of ions calculated as similar to Piper (1944), Hill, (1940), Hem (1985).

CONCLUSION

The present investigation indicates alkaline nature of river in the study area. Water quality evaluation for drinking purposes in accordance with BIS (1993) and WHO (1970). TDS, pH, total hardness, total alkalinity, DO, bicarbonate, carbonate, phosp-

Table 6. *Major Ions concentrations in river Mandakini water of Jankikund*

Jankikund	Summer			Post-monsoon			Winter		
major ions	mg/L	m.eq/L	%	mg/L	m.eq/L	%	mg/L	m.eq/L	%
HCO_3^-	128.2	2.1	85.2	133.52	2.18	84.0	126.77	2.07	84.1
SO_4^{2-}	8.37	0.17	5.5	9.95	0.2	6.3	8.77	0.18	5.8
Cl^-	14.0	0.39	9.3	15.5	0.43	9.7	15.3	0.43	10.1
Ca^{2+}	41.12	2.05	41.0	42.22	2.1	39.2	42.1	2.1	41.2
Mg^{2+}	32.45	2.7	32.3	37.43	3.1	34.7	32.25	2.68	31.7
Na^+	16.4	0.71	16.0	17.35	0.75	16.2	16.8	0.73	16.4
K^+	10.4	0.26	10.7	9.97	0.27	10.9	10.9	0.27	10.7

Table 7. *Major ions concentrations in river Mandakini water of Ramghat*

Ramghat	Summer			Post-monsoon			Winter		
major ions	mg/L	m.eq/L	%	mg/L	m.eq/L	%	mg/L	m.eq/L	%
HCO_3^-	128.4	2.1	82.5	135.2	2.2	81.6	128.6	2.1	82.0
SO_4^{2-}	11.12	0.23	7.2	12.7	0.26	7.6	11.7	0.24	7.5
Cl^-	16.0	0.45	10.3	17.9	0.5	10.8	16.52	0.46	10.5
Ca_2^+	41.35	2.06	40.2	43.9	2.2	38.8	40.9	2.04	39.7
Mg^{2+}	32.9	2.74	31.9	38.6	3.2	34.2	33.35	2.77	32.3
Na^+	17.4	0.75	16.9	18.6	0.8	16.3	17.42	0.75	16.9
K^+	11.4	0.29	11.0	12.0	0.3	10.7	11.35	0.29	11.1

Table 8. *Major ions concentrations in river Mandakini water of Karwi*

Karwi	Summer			Post-monsoon			Winter		
major ions	mg/L	m.eq/L	%	mg/L	m.eq/L	%	mg/L	m.eq/L	%
HCO_3^-	124.9	2.03	80.0	128.02	2.09	79.0	126.25	2.06	79.5
SO_4^{2-}	13.62	0.28	8.7	15.02	0.31	9.2	14.27	0.29	9.0
Cl^-	17.67	0.49	11.3	19.2	0.54	11.8	18.2	0.51	11.5
Ca^{2+}	39.3	1.9	39.3	48.2	2.4	41.6	39.1	1.95	39.5
Mg^{2+}	31.02	2.6	31.0	36.8	3.06	31.8	30.6	2.54	30.9
Na^+	17.7	0.76	17.7	18.4	0.8	15.9	17.6	0.76	17.3
K^+	11.97	0.3	12.0	12.45	0.32	10.7	11.75	0.3	11.8

Table 9. *Major ions concentrations standards*

Major ions	US permissible limit			UN permissible limit			WHO permissible limit			ISI permissible limit		
	mg/L	m.eq/L	%	mg/L	m.eq/L	%	mg/L	m.eq/L	%	mg/L	m.eq/L	%
HCO_3^-	–	–	–	–	–	–	500	8.1	39.9	–	–	–
SO_4^{2-}	250	5.2	42.6	200	4.1	42.2	250	5.2	25.6	150	3.1	30.6
Cl^-	250	7.0	57.3	200	5.6	57.7	250	7.0	34.4	250	10.1	69.3
Ca^{2+}	–	–	–	75	3.7	47.4	200	10.0	49.0	75	3.7	75.5
Mg^{2+}	125	10.4	100	50	4.1	52.5	125	10.4	50.9	30	1.2	24.4
Na^+	–	–	–	–	–	–	–	–	–	–	–	–
K^+	–	–	–	–	–	–	–	–	–	–	–	–

hates, nitrate, chloride, sulphate, Ca^{2+}, Mg^{2+}, Na^+ and K^+ at all sampling stations were found below the desirable limit. Calcium and magnesium are dominating cations (accounting for about 65 to 75 % of the total cations) and bicarbonate anions (accounting for about 75 to 89 % of total anions) were found dominating in the river water. Potential environmental effects on hydrological systems, impact of

river water, quality and social impacts on land use, vegetation, wild life and habitats generated by proposed river activity should be assessed properly.

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