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ASSESSMENT OF WATER QUALITY OF RIVER MANDAKINI FOR DRINKING PURPOSE IN STRETCH OF CHITRAKOOT AREA

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ABSTRACT

Present study deals with assessment of water quality of the river Mandakini for drinking purpose in a stretch of Chitrakoot area. The river Mandakini is one of the minor sacred rivers of Madhya Pradesh especially of Chitrakoot area, the eastern part of Bundelkhand region, sharingwater between MP and UP. It originates from Kelhaura hills about 45 Km in south-west of Chitrakoot and finally joins in the river Yamuna near Rajapur about 40 Km. in northeast of Chitrakoot. The sampling stretch covers approximately 25 km length from Sati Anusuiya to downstream of Karwi Bridge. The selected sampling stations were Sati Anusuiya (SA), Sphatikshilla (SS),Arogyadham Pool (ADP), Jankikund (JK), Pramodvan (PV), Bharat Ghat (BG), Ramghat (RG), Karwi Bridge Upstream (KBU) and Karwi Bridge Downstream (KBD). The parameters investigated were temperature, pH, turbidity, chloride, alkalinity, hardness, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), bio-chemical oxygen demand (BOD), chemical oxygen demand (COD) and total coliform count (TC). These parameters were determined in the laboratory by following the standard methods for examination of water and wastewater (APHA-AWWA, 2012). Investigated parameters were compared with their standards prescribed by BIS and CPCB. Based on results, it was concluded that the quality of river water was not fit for drinking purpose except at SA, SS and ADP sampling stations.

KEY WORDS : River water quality, River pollution, Chitrakoot, Water pollution

INTRODUCTION

Water is the most vital and energy resource for the living organism. Human beings rightly judged the importance of the water as resource in various areas, like domestic,agriculture cumaquaculture, industry, power, recreation, navigation etc. Now quality of water both the surface and ground water is being deteriorated continuously due to discharge of untreated domestic and industrial wastes and wastewater through drains to open land as well as to surface water bodies (Gupta *et al.*, 2010). Therefore, conservation and procurement of water resources needs a serious and immediate attention through periodical checkup of water quality and its subsequent management if necessary. The river Mandakini is one of the holy rivers of Madhya Pradesh especially of Chitrakoot area, the eastern part of Bundelkhand region, sharing water between MP and UP. It originates from Kelhaura hills about 45 Km. in south-west of Chitrakoot and finally joins in river Yamuna near Rajapur about 40 Km in north-east of Chitrakoot. Chitrakoot is situated at 25^0-31′N latitude and 80^0-81′longitude. Map of the stretch of the river Mandakiniis shown in Fig. 1. River water was subjected to pollution due to direct discharge of domestic, industrial, agricultural wastewaters, etc. through drains/nallas into the river. Most of the Chitrakoot towns/city is located on the bank of the river Mandakini.

A detailed study was carried out on assessment of the pollution load due to various drains entering the river Mandakini, Chitrakoot (MP part), India by Gupta *et al.,* (2014). The study revealed that 16 small and big drains/nallas entered the river Mandakini. In which Vaidehi Vatika and Paisunidrains are big drains discharging more wastewater and deteriorate the river water quality in point of view of pollution loads. Various studies were carried out on physico-chemical and biological assessment of water quality of the river Mandakiniat Chitrakoot by Agrawal and Kannan, 1994; Agrawal, 1996; Kannan, 1996; Kannan and Chaurasia, 1996; Chaurasia and Agrawal, 2002; Garg, 2002; Gupta *et al.,* 2010; Gupta and Gupta, 2012, etc. and reveled that quality of river water was found to differ time to time on various stations.Similar studies were also carried out on different rivers by various scientists including Chatterjee *et al.,* (2010) who studied on an assessment on the water quality parameters such as physico-chemical and bacteriological analysis from a point source of the river Damodar West Bengal, India during the period of 2004–2007. The mean values of the physicochemical and biological parameters of the river water at the sampling siteswere consistently higher than the prescribed levels specifiedby WHO and other regulatory bodies. Singh and co-workers (2005) studied on various physico-chemical parameters such as pH, alkalinity, hardness, EC, TDS, BOD, etc. applying to the data set on water quality of the Gomti river, India. The monitoring at eight different sites of above river was carried outduring three years (1999–2001). The study revealed that soil weathering, leaching and runoff; municipal and industrial wastewater; waste disposal sites leaching were among the major sources/factors responsible for river quality deterioration. An investigation as physico-chemical parameters of water samples of the river Ganga at Kanpur was carried out by Trivedi *et al.*, (2009). Water samples under investigations were collected during pre-monsoon (April - May), monsoon (July - August) and post monsoon (October - November) seasons in the year

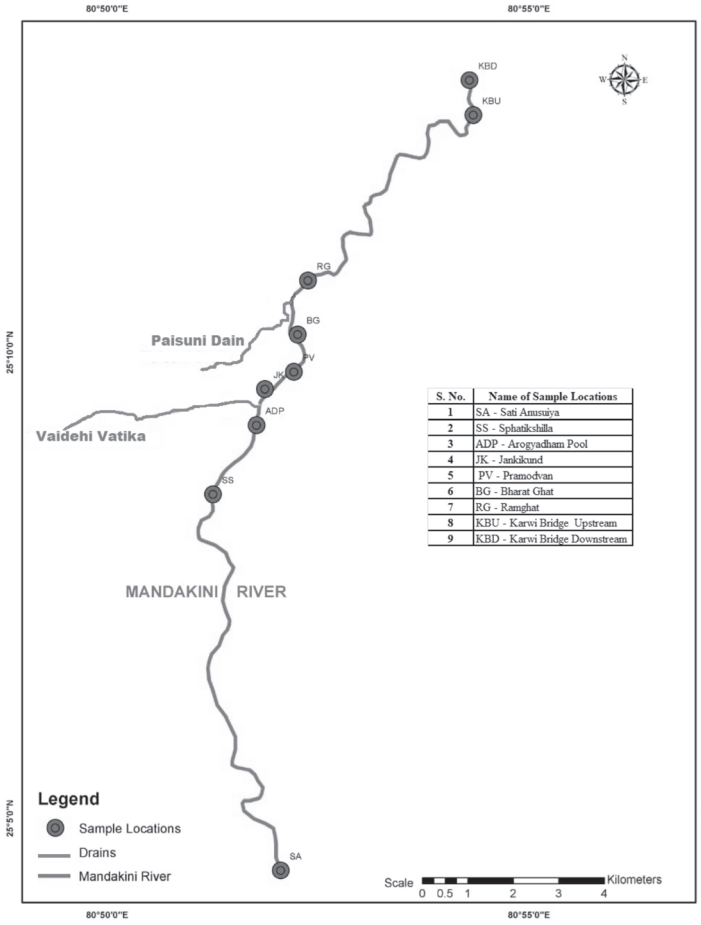

Fig. 1. Map of the river Mandakini

2008. The observed values of different physico-chemical parameters like pH, temperature, turbidity, total hardness, chloride, total dissolved solids, total alkalinity, etc. of samples were compared with standard values recommended by world health organization (WHO). The literatures on study of water quality of river Mandakini showed that most of the studies of water quality assessment of the river Mandakini at Chitrakoot were carried out on either lean season or special events. There was no such special case found out so far to check the water quality after passing the monsoon. In this regards, keeping the above point is mind the study was planned to analyse the water sample of the river Mandakini at different sites as physico-chemical and biological parameters in post monsoon period.

MATERIALS AND METHODS

Nine sampling sites were selected for the study of physico-chemical and biological monitoring of water in order to know its suitability for drinking purposes. The monitoring was performed in post monsoon period from September 2015 to December 2015. Details of the sampling sites are given in Table 1. Water samples were collected in pre-cleaned polypropylene bottles with necessary precautions. Samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD) analyses were taken in BOD bottles. The temperature and dissolved oxygen (DO) were analyzed at sampling sites while other parameters were determined in the laboratory following the standard methods for examination of water and wastewater (APHA-AWWA, 2012). Glassware used in the study were of high quality borosilicate brand (Schott duran, Germany). Chemicals used were of AR/GR grade and obtained from Qualigen/ E-Merck/Hi-media.

RESULTS AND DISCUSSION

The average monitoring results of physicochemical and biological parameters of the river Mandakini were mentioned in Table 2. Standard values of various parameters for drinking water were also given in table 3(BIS, 2012 and CBCB. 1976) for comparison of the obtained results.

From Table 2 it is cleared that temperature was found in the range of 20 to 23.5 ^{0}C. Minimum temperature was observed as 20^{0}C at SA while maximum was recorded as 23.5 ^{0}C at Karwi bridge downstream. The temperature plays a vital role in the chemical and biological activities of water body for organism. The increase in temperature decreases portability because at elevated temperature carbon dioxide and other gases which impart taste are expelled (Vimla *et al*., 2006). Temperatures values were under the limit of their ideal temperature ranged, i.e. 20-27 ^{0}C (Fig. 2).

pH value (Table 2) indicated that at all places water was slightly alkaline in nature.pH slightly

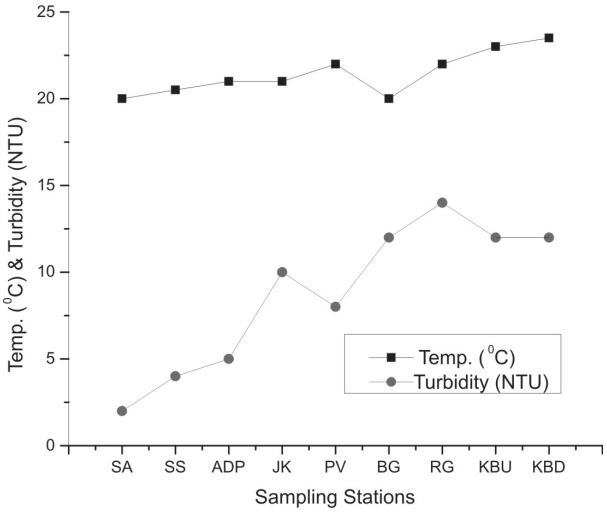

Fig. 2. Variation of temperature and turbidity at different sampling stations.

Table 1. Details of sampling stations.

S. No.	Sampling station	Location
1	Sati Anusuiya (SA)	A upstream station, ~15 Km in the south of Chitrakoot
2	Sphatikshilla (SS)	A upstream station, ~3.0 Km in the south of Chitrakoot
3	Arogyadham Pool (ADP)	A midstream station, ~2.0 Km in the south of Chitrakoot
4.	Jankikund (JK)	A midstream station, ~1.5 Km in the south of Chitrakoot
5.	Pramodvan (PV)	A midstream station, ~1.0 Km from Chitrakoot
6.	Bharat Ghat (BG)	A downstream station, 0 Km from Chitrakoot
7.	Ramghat (RG)	A downstream station, ~0.5 Km in the north of Chitrakoot
8.	Karwi Bridge Upstream (KBU)	A downstream station, ~10 Km in the north of Chitrakoot
9.	KarwiBridge Downstream (KBD)	A downstream station, ~11 Km in the north of Chitrakoot

shifted to more alkaline region, i.e 7.2 at ADP to 7.8 at PV. Since the place is a storehouse of limestone rocks consequently increase in pH in all stations of river (Fig. 3).

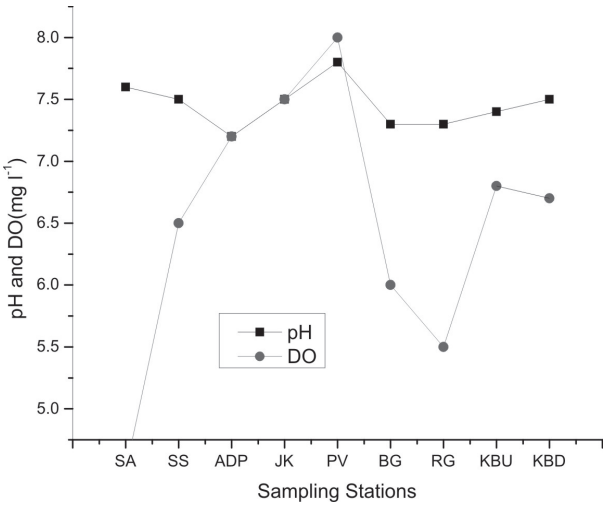

Fig. 3. Variation pH and DO at different sampling stations

Value of turbiditywas varied from 2.0 to 14.0 NTU (Table 2 and Fig. 2). Minimum and maximum values were found at SA and RG, respectively. Values of turbidity at all the stations except at SA, SS and ADP were higher than their permissible limit, i.e. 05 NTU prescribed by BIS, (2012) (Table 3). Higher values of turbidity were due to presence of clay, silt, organic mattersand partially hydrolyzed metals. Phytoplanktons and other microorganisms were measured photo metrically also contributed turbidity in natural water (Kotaiah and Kumaraswamy, 1994).

Table 2 also showed that chlorides were found in the range of 20 to 55 mg/l. Minimum value was observed at SA while maximum was recorded at Karwi bridge downstream. Values of chlorides was started to be increased from JK to Karwi bridge downstream due to a lot of small and big drains entering the river courses (Fig. 4).

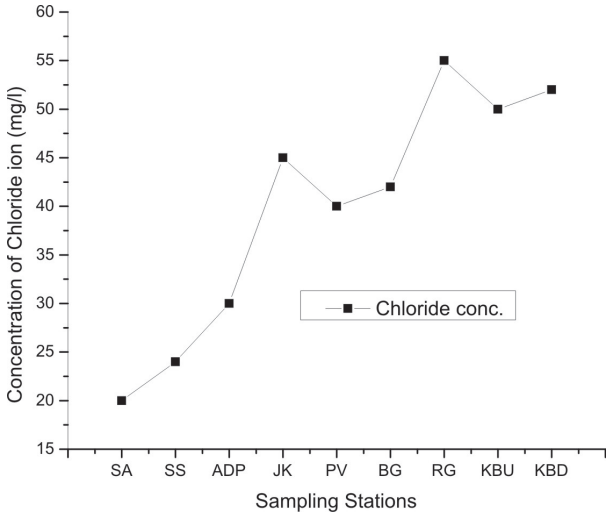

Fig. 4. Variation of chloride ion concentration at different sampling stations.

Extent of alkalinity was found in the range of 180-200 mg/l given in Table 2 & Fig. 5. Lower limit was recorded at KBD and higher limit was recorded at SA. Higher value of alkalinity at SA is justified on account of much occurrence of carbonate rocks therein.

Hardness wasfound in the range of 197-261 mg/l (Table 2 and Fig. 5). Maximum and minimum values were recorded at SA and Karwi bridge downstream, respectively. Since SA was a hilly area consisting of limestone rocks so higher value was found in the study area.

Table 2. Average results of selected physicochemical and biological parameters at various stations of the river Mandakini from Sept. 2015 to Dec.2015.

Sampling Stations	Parameters											
	Temperature (°C)	pH	Turbidity (NTU)	Chloride (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	EC µmho/cm	TDS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	TC MPN /100 ml
SA	20	7.6	2	20	200	261	492	320	4.5	2.0	4	4
SS	20.5	7.5	4	24	198	255	476	310	6.5	2.4	5	24
ADP	21	7.2	5	30	195	248	469	305	7.2	3.0	8	45
JK	21	7.5	10	45	192	240	500	325	7.5	8.0	12	900
PV	22	7.8	8	40	190	212	480	312	8.0	7.0	10	900
BG	20	7.3	12	42	196	215	489	318	6.0	12.0	18	≥ 1600
RG	22	7.3	14	55	198	220	538	350	5.5	15.0	25	≥ 1600
KBU	23	7.4	12	50	182	202	523	340	6.8	12.0	20	1600
KBD	23.5	7.5	12	52	180	197	526	342	6.7	14.0	22	1600

Electric conductivity is a measurement of water capacity for conveying electric current and is directly related to the concentration of ionized substance in the water. It always correlates with TDS. Value of EC was found in the range of 469 to 538µmho cm^{-1} (Table 2 and Fig. 6). Lower value of EC i.e. 469 at ADP is due tohuge mass of germinated phytoplankton at this site might absorb some ionic substanceand consequently reduced their concentration. Maximum concentration was found i.e. 538 at RG. Maximum concentration was due to discharging the wastewater through Paisuni drain contributed more EC.

It is obvious from Table 2 that TDS ranges from 305-350 mg/l. Minimum and maximum values were recorded at ADP and RG, respectively. All value was found within permissible limit (Fig. 6). TDS consists of inorganic substance such as calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate, etc. in water (Muduli *et al*., 2006).

Table-2 showed that value of DO was found in the range from 4.5 to 8.0 mg/l. Maximum value was recorded at PV while minimum at SA(Fig. 3). Since at SA water was just receiving from ground water source around of mountain so minimum value of DO was observed therein while maximum value PV

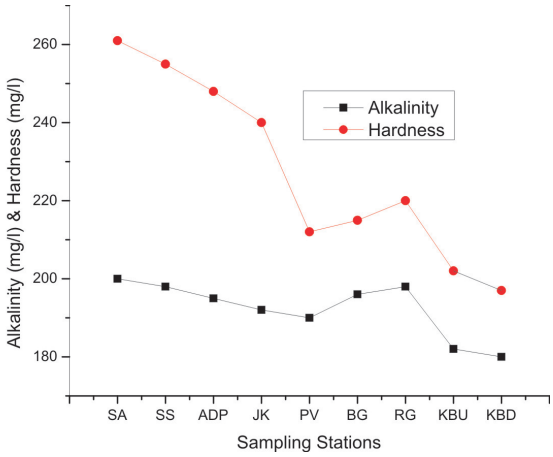

Fig. 5. Variation of alkalinity and hardness at different sampling stations

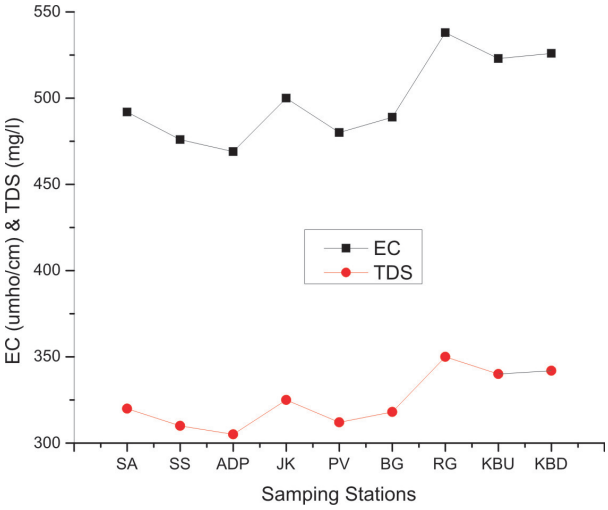

Fig. 6. Variation of EC and TDS at different samping stations.

Table 3. Drinking water quality standards

S.No.	Parameters	Maximum Permissible Limit			
		Bureauof Indian Standard (BIS,2012)		Classification of Surface Water in India by CPCB (1976)	
		Requirement acceptable limit	Permissible limit in the absence of alternative source	Drinking water source without conventional treatment but after disinfection (A-Class Water)	Drinking water with conventional treatment followed by disinfections (C-Class Water)
1.	pH	6.5-8.5	No relaxation	6.5-8.5	6.5-8.5
2.	Turbidity (NTU)	1	5	-	-
3.	Chloride (mg/l)	250	1000	-	-
4.	Alkalinity (mg/l)	200	600	-	-
5.	Total Hardness as $CaCO_3$ (mg/l)	200	600	-	-
6.	EC (µs/cm)	-	-	-	-
7.	TDS mg/l	500	2000		
8.	DO (mg/l)		-	6 or more	4 or more
9.	BOD (mg/l)		-	2 or less	3 or less
10.	COD (mg/l)	-	-	-	-
11.	FC/TC (MPN/100ml)	-	-	50	5000

due to shallow depth and high flow contributed high DO. Besides much quantity of algae germinated on river bed of limestone which may be attributed to active photosynthesis by plants (Rai *et al.*, 1984).

BOD values were found in the range of 2.0 to 15 mg/L. Higher value was recorded at RG due to the domestic waste and agriculture waste joins to the river and thus contributes more value of BOD. BOD value is under limitat SA and SS (upper reach), ADP (middle reach) indicate that low level of biodegradable materials and absenceof non-biodegradable materials in the above sites of river (Table 2 & Fig. 7).

Table 2 also showed that COD was found in the range of 4 to 25 mg/l. Maximum and minimum value was found at RG and SA, respectively. Higher contribution of CODthan BOD at all stations. Generally, COD is always greater than BOD. Because COD analysis covers nearly 100% of both biodegradable and non-biodegradable organic matters and even some ox disable inorganic compounds. This is why COD increased at all stations especially from JK to KWD stations due to various inorganic-organic species reaching to the river from drainage (Fig. 7).

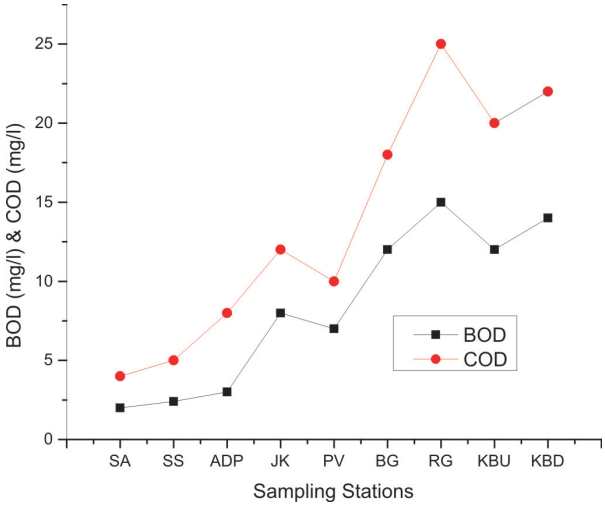

Fig. 7. Variation of BOD and COD at different sampling stations

Extent of TCwas almost high at most of the stations (Table 2) than the recommended limit of TC is 50 MPN/100 mL (Table 3). Higher values of TC were increased from JK to KBD (Fig. 8) and SA where minimum value of TC was found, i.e. 04 MPN/100 mL. Higher value of TC recommended that the river water is unfit for drinking purpose

CONCLUSION

Based on findings of study, it was concluded that quality of river water was not fit for drinking purpose except at SA, SS and ADP stations. However, the river was found to be slightly polluted in terms of turbidity, BOD, COD and total coliform estimations at JK, PV, BG, RG, KBU and KBD. So we can say that water is safe only at Sati Anusuiya (SA), Spatikshilla (SS) and Arogyadham pool (ADP)for drinking purposes. So it can be recommended that river may be designed as safe zone from Sati Anusuiya to Arogyadham pool (ADP). The other reaches from JK to KBD may also be designed as slightly polluted zone. Since from JK to RG many small and two big drains viz. Paisuni andVaidehiVatika are discharging their wastewater enhancing organic and inorganic load in to river and deteriorated its quality. Although MP Govt. has initiated to establish a sewage treatment plant (STP) at Ramghat for treating the wastewater of the area. However, it is 'further' suggested that drains should be tappedor diverted for other sides passingthrough plants-bioremediation prior to falling the river Mandakini.

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