



Water Quality and Pollution load of River Mandakini at Chitrakoot, India

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Abstract

The rivers in India have religious importance. Water, especially river water subjected to pollution due to direct discharge of domestic sewage, industrial waste, Agricultural run-off, etc. into the river. Most of the major towns are located on the catchment area of river systems, discharging their wastewater directly or indirectly into surface water bodies e.g. rivers, etc. The detailed survey of river revealed that small areas as well as large areas which fall in the way of river, dump domestic and toxic wastes in the river rendering serious environmental problems posing threat on human beings and biodiversity. The point sources discharge of domestic sewage or wastewater through open drains or sewerage system, etc. The non-point sources of pollution are agriculture runoff, washing of cloths, cattle wallowing and throwing of carcasses or half burnt dead bodies etc. The pollution potential of the riverine system has increased, which has not only degraded the quality of water of these rivers but also has affect the flora and fauna. The various pollutants entering into eco-system through drains may be bio-degradable and non-biodegradable; these pollutants have also higher BOD and COD level. Keeping the above points in mind, the study of river and various drains joining to the river Mandakini at Chitrakoot has been selected for the study.

Keywords: Pollution load, point source, drains, physico-chemical and quality.

Introduction

The river Mandakini originates from hills of Khillora near Pindra village, Majhagawan block (25° 09'24.8" N, 80° 52' 55.3"E), Satna district, M.P. at an elevation of 156 meter above mean sea level in the state of Madhya Pradesh of northern India. Whole watershed area is 1956.3 sq. km. The river passes through two states especially between M.P. and U.P. states. Sati Anusuiya is a perennial reach of Mandakini River where a large number of small and big springs feed to the river. Afterwards it passes through various religious and non-religious points. This study covers MP and UP part in 23.5 km stretch starting from Sati Anusuiya to Khatkyana. River stream flows from south to north direction. It is a life line of Chitrakoot. Number of drains carrying the waste water of town joining the river at various points increasing the pollution load in the river and altering the water quality^{1,2}.

Objectives of Study: i. To prepare the inventory of existing drains joining the river Mandakini. ii. To measure the existing pollution load of sampling station and selected drains joining the river Mandakini. iii. To measure the flow of drains and river. iv. To monitor of water quality of river and selected drains with the help of various physico-chemical parameters.

Material and Methods

On the stretch of river (23.5km) three sampling stations were selected. One sampling station Arogyadham was in MP part and two sampling stations namely Ramghat and Kawi ghat were in

UP part. Five major drains were selected for study. The details of drains are given in table-1.

Table-1
Description of selected drains

Selected Drains	Description
Vaidehi Vatika drain	This drain is situated at 12 km in downstream of Sati Anusuiya. It collects wastewater of western and southern part of Jankikund locality of Chitrakoot and joins to the river Mandakini. It covers wards No. 10 and 11.
Paisuni drain	Paisuni drain situated on Ramghat. It is a major drainage collecting wastewater from northern and western MP and UP part of Chitrakoot.
Sitapur slope drain	This drain is situated 0.7 km downstream of Ramghat. In this reach the river is shallow, narrow with high flow. It collects wastewater of western and southern parts of Sitapur locality of Chitrakoot.
Taraunha main drain	This drain is situated at 3.5 km of Ramghat. It collects wastewater of eastern, northern and southern parts of Taraunha locality of Chitrakoot, UP.
Karwi bridge drain:	6.0 km downstream of Ramghat. It collects wastewater from western and southern parts of Chitrakoot, UP.

Composite water samples were collected from selected sampling stations of drains and river Mandakini in two liter clean polythene cans. Monitoring was carried out for three month on monthly basis. Physico-chemical parameters such as temperature, pH, and turbidity, EC, TDS, TSS, TS, DO, BOD, COD, Nitrate and Phosphate were analyzed as per Standard Method^{3,4}. Morpho-metric character (depth, length, width), velocity, flow rate and pollution load of river and selected drains were measured.

Results and Discussion

The result of the physico-chemical characteristics of river water and drains waste water are given table-1-3 and 6-8 and flow rate are given table 9-10.

Temperature: The temperature of water which is an ideal for the biological activities of microorganism is 20-25°C. During study, temperature of river range 23°C-25°C table-1-3. Minimum temperatures was record 23°C at Arogyadham in May. Maximum temperature was record 25°C at Karwi ghat in July. The drains water temperature recorded in the range of 23°C-25°C as it depends on atmospheric temperature⁵.

Total Solids (TS): Total dissolved solids (TDS) of river water was ranged from 320-490 mg/l while Total suspended solid was found in the range 110-218 mg/l (table1-3) and total solids was ranged from 402-700 mg/l table-1-3.

Minimum value of TDS 320 mg/l was observed at Arogyadham in May, while maximum value of TDS was 490 mg/l at Karwi ghat in July. Minimum value of TSS was observed 110 mg/l at Karwi ghat in May, while maximum value i.e. 218 mg/l at Karwi ghat in July.

Minimum value of TS was observed 402 mg/l at Karwi ghat in May, while maximum value was 700mg/l at Karwi ghat July. The average TDS and TS observed at different station are shown in figure-1.

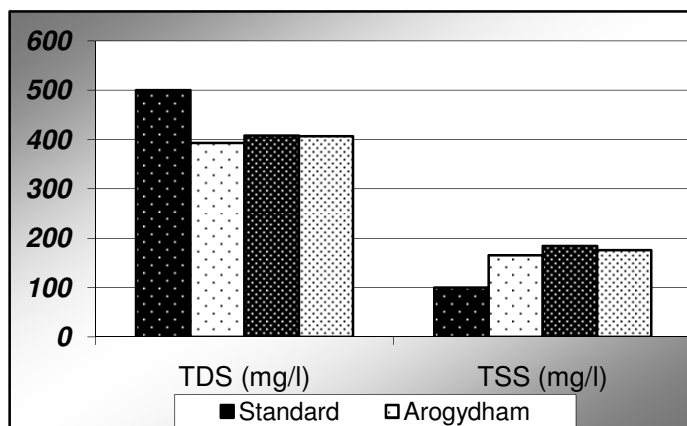


Figure-1
TDS and TSS at various stations of River Mandakini

Total dissolved solids of drains was ranged from 512-792 mg/l while total suspended solids was ranged from 225-344 mg/l. Total Solids were found in the range of 737-1136 mg/l table 6-8.

Minimum value of TDS was observed 512 mg/l at Sitapur slope in May, while maximum 792 mg/l at Paisuni in July. Minimum TSS was found 225 mg/l at Sitapur slope in May, while maximum 344 mg/l was found at Paisuni drain in July.

Minimum value of T.S was observed 737 mg/l at Sitapur slope in May, while maximum 1136 mg/l at Paisuni in July. The average TDS and TS observed for drains are shown in figure-5.

pH: The pH value of river was recorded between 7.9-8.3 table-1-3. Minimum pH of river water was observed 7.9 at Arogyadham in May, while maximum 8.3 at Karwi ghat in July⁶.

The pH value of drains water was recorded in ranged of 7.2 to 8.2 table 6-8. Minimum pH was observed 7.2 at Sitapur slope in June, while maximum pH value 8.2 at Paisuni drains in July.

Electrical Conductivity (E.C.): The EC value of river was ranged from 398-482 µmho/cm table-1-3 Minimum value of EC was observed 398 µmho/cm at Arogyadham in May, while maximum 482 at Karwi ghat in July. The average E.C. observed at different station is shown in figure 2.

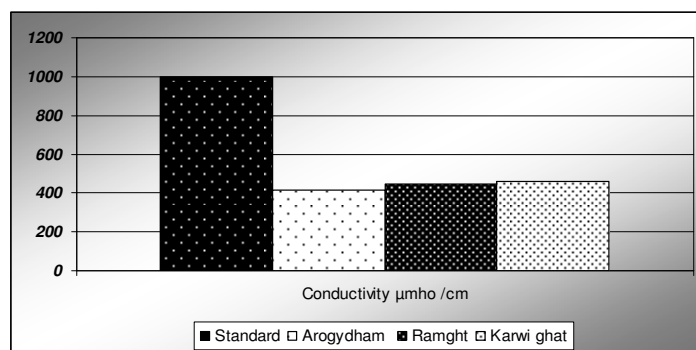


Figure-2
Conductivity at various station of River Mandakini

EC value was found higher for drains waste water was ranged from 940-1190 µmho/cm table-6-8. Minimum value of EC was observed 940 µmho/cm at Vaidehi vatika in May, while maximum value of EC 1190 µmho/cm at Paisuni drains in July. The average E.C. observed at different station is shown in figure-6.

Dissolved Oxygen (DO): In river stretch dissolved oxygen (DO) was ranged from 8.2-9.9 mg/l table-1-3. The minimum value of DO was found 8.0 mg/l at Karwi ghat in May, while maximum 9.9 mg/l at Arogyadham in July.

The DO of drains was ranged in 1.2-4.8 mg/l table-6-8 Lowest value 1.2 mg/l were recorded at Sitapur slope in May, while

highest value 4.8 mg/l at Taraunha in June. Both values were below the permissible limit 5 mg/l. indicating that it has higher organic matter⁶. Similar value observed in city of So- Ava in Benin Republic⁷ and Andhra Pradesh⁸.

Biochemical Oxygen Demand (BOD): In river stretch BOD was ranged from 1.3-6.8 mg/l. lowest value was 1.3 mg/l at Arogyadham in July, while highest value was 6.8 mg/l at Karwi ghat in May. The average DO and BOD observed at different stations are shown in figure 3.

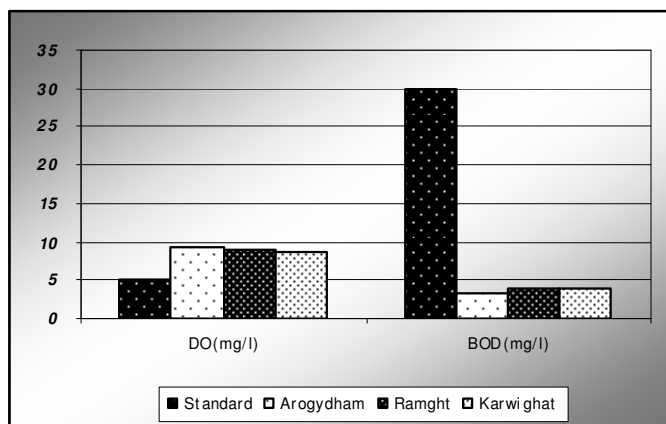


Figure-3

DO and BOD at various station of River Mandakini

The value of drains water was the in range of 32-68 mg/l table-6-8. Lowest value was 32 mg/l at Taraunha in June, while highest value was 68mg/l at Sitapur slope in May The average DO and BOD observed at different stations are shown in figure-7.

Chemical Oxygen Demand (COD): COD of river water was ranged 30-45 mg/l table-1-3. Lowest value was 30 mg/l at Arogyadham while highest value was 45 mg/l at Karwi ghat in May. Average COD observed at different stations are shown in figure 4.

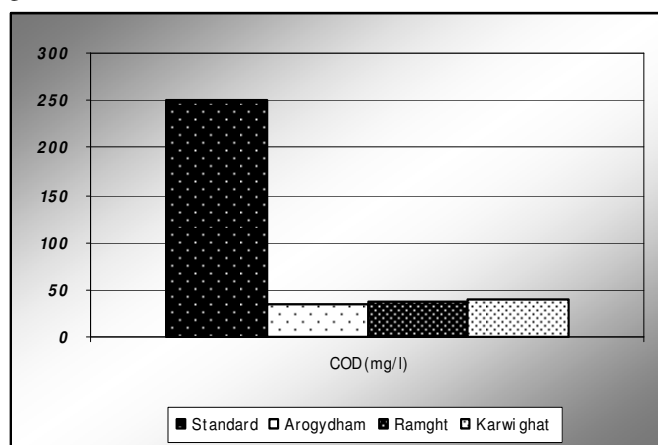


Figure-4

COD at various station of River Mandakini

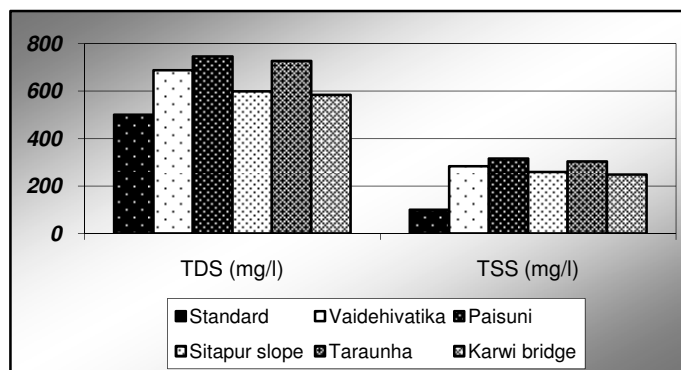


Figure-5

TDS and TSS of selected drains

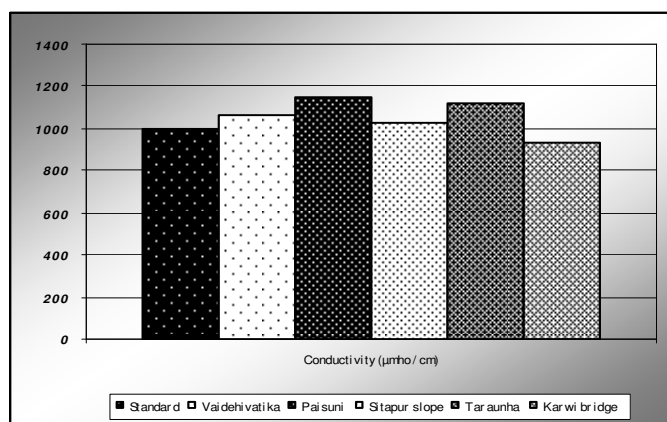


Figure-6

Conductivity of selected drains

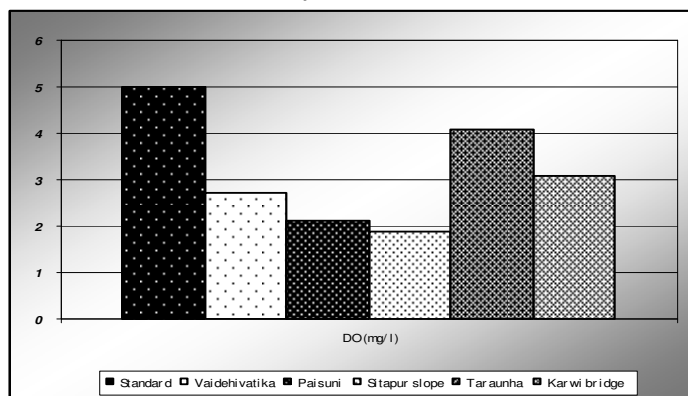


Figure-7

DO of selected drains

COD of drains was found in the range of 92-140 mg/l table-6-8. Lowest value was 92 mg/l at Taraunha in June, while high value was 140 mg/l at Sitapur slopes May and July. COD observed at different stations are shown in figure-8.

Nitrate(NO_3^-): The value of Nitrate was recorded in the range of 0.44-0.83 mg/l table-1-3 minimum value was found 0.44 mg/l at Arogyadham in May, while maximum value 0.83 at Karwi ghat in June.

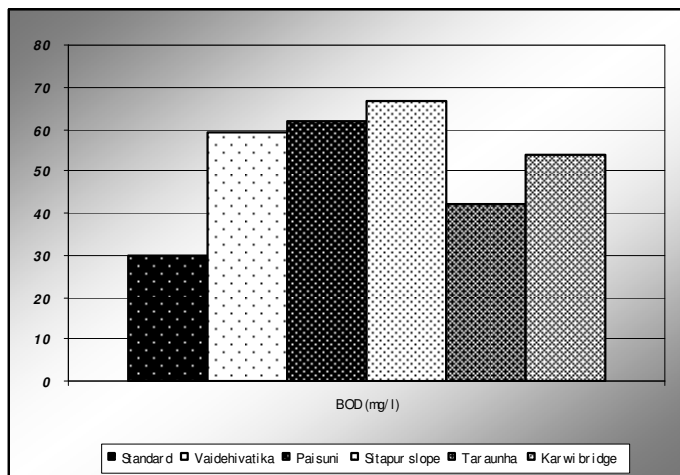


Figure-8
BOD of selected drains

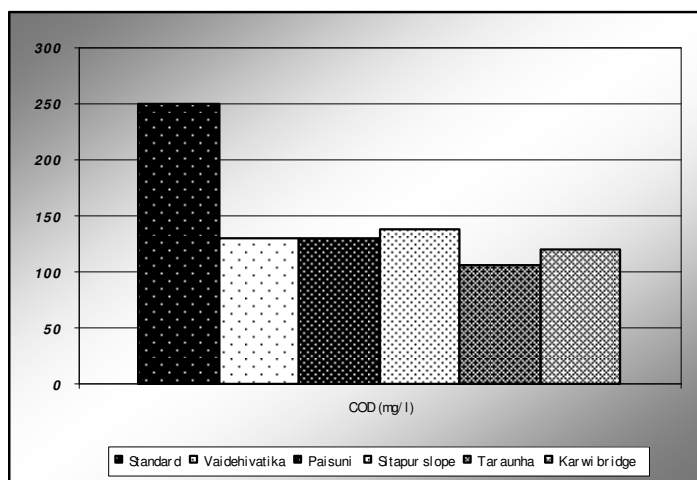


Figure-9
COD of selected drains

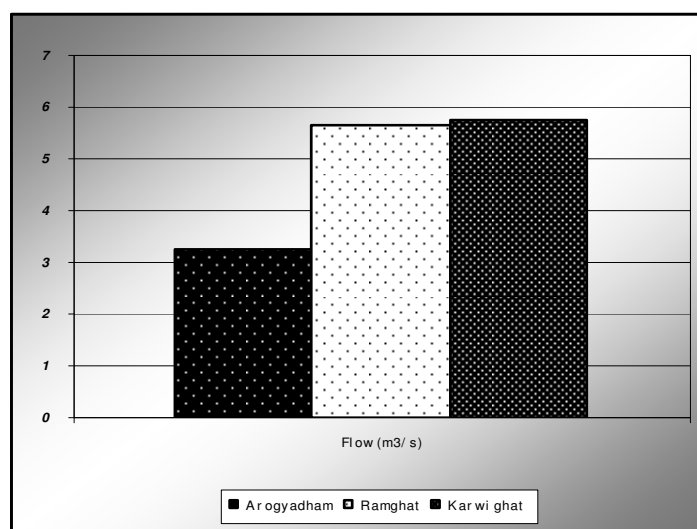


Figure-10
Average flow rate of river

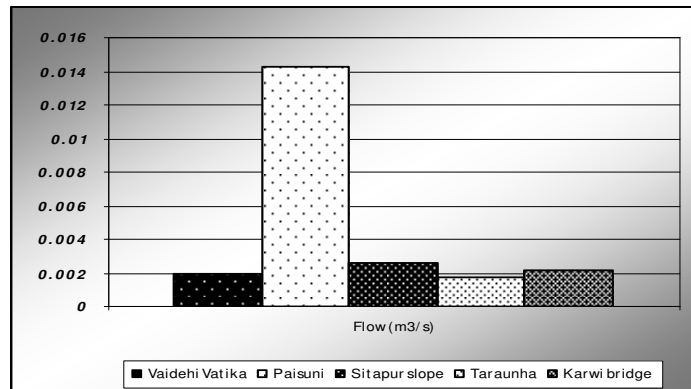


Figure-11
Average flow rate of drains

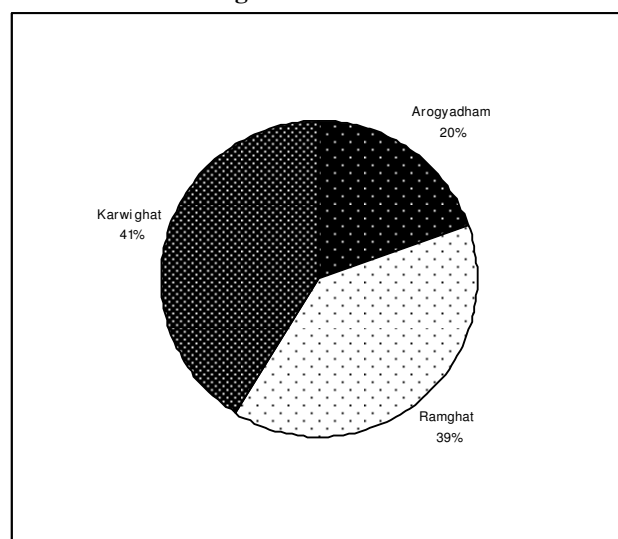


Figure-12
Pollution load of different station of River Mandakini

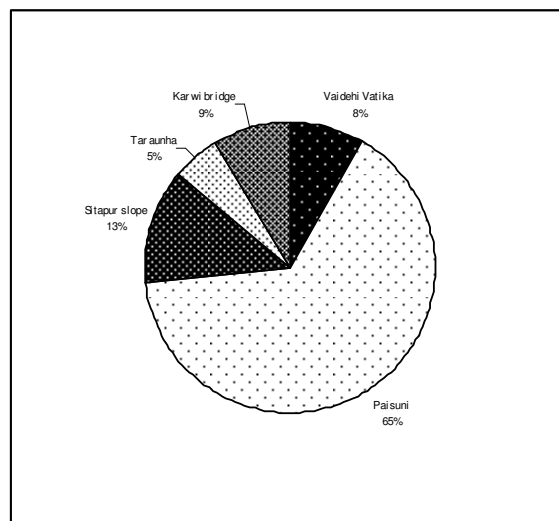


Figure-13
Pollution load of drain

Phosphate (PO_4^{--}): The value of phosphate was found in range of 0.27-0.65 mg/l. table-1-3 minimum value was found 0.27 mg/l at Arogyadham in May, while maximum was found 0.65 mg/l at Karwi ghat in June.

Flow rate: Flow rate of water depends upon velocity and area (m^3). Flow rate = area (A) x velocity (V) = m^3/s

Average flow rate of river varied from 3.2313-5.728 m^3/s . table-9-10. Minimum flow was found at Arogyadham while maximum at Karwighat. The total average flow rate of river value was found 4.869 m^3/s while drain value varied from 0.0017 m^3/s to 0.0143 m^3/s . Minimum value was found for Taraunha drains and maximum value was found for Paisuni drains.

Pollution load: Assessment of pollution load is a useful parameter to check the strength of waste water. The pollution load of various river and drains was determined and mentioned in table 5 and 10. The pollution load of river water was found in the range of 940.76-1979.60 kg/day. Minimum pollution load was found 940.67 Kg/day at Arogyadham while maximum value was found 1979.60 Kg/day at Karwi bridge.

Pollution load of drains waste water was found in the range of 6.17-76.60 Kg/day Minimum pollution load was found 6.17 Kg/day at Taraunha while maximum value was found 76.60 Kg/day at Paisuni.

Table-1
Physiochemical quality of river Mandakini May, 2012

Station	Parameters										
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. $\mu\text{mho}/\text{cm}$	DO mg/l	BOD mg/l	COD mg/l	NO_3^{--} mg/l	PO_4^{--} mg/l
Arogyadham	23	7.90	320	142	462	398	8.50	6.20	35	0.44	0.27
Ramghat	25	8.20	328	160	488	418	8.30	6.50	43	0.56	0.42
Karwighat	25	8.30	292	110	402	412	8.00	6.80	45	0.72	0.52

Table-2
Physiochemical quality of river Mandakini June, 2012

Station	Parameters									
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. $\mu\text{mho/cm}$	DO mg/l	COD mg/l	NO_3^- mg/l	PO_4^{--} mg/l
Arogydham	23.67	8.03	393.33	165.00	558.33	414.00	9.27	33.53	0.50	0.31
Ramght	25.00	8.17	408.00	184.33	592.33	447.33	8.87	38.00	0.56	0.46
Karwi ghat	25.33	8.27	407.00	175.67	580.33	457.33	8.70	39.37	0.73	0.59

Table-3
Physiochemical quality of river Mandakini July, 2012

Station	Parameters										
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. $\mu\text{mho}/\text{cm}$	DO mg/l	BOD mg/l	COD mg/l	NO_3^{--} mg/l	PO_4^{--} mg/l
Arogyadham	24	8.20	398	171	569	412	9.40	2.60	30	0.56	0.31
Ramghat	25	8.10	428	193	621	460	9.00	3.20	32	0.62	0.48
Karwi ghat	25	8.10	440	199	639	478	9.20	2.80	30	0.83	0.68

Table-4
Average physiochemical quality of river Mandakini (2012)

Station	Parameters										
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. $\mu\text{mho}/\text{cm}$	DO mg/l	BOD mg/l	COD mg/l	NO_3^{--} mg/l	PO_4^{--} mg/l
Arogydham	24	8.00	462	182	644	432	9.90	1.30	35.60	0.49	0.36
Ramghat	25	8.20	468	200	668	464	9.30	2.00	39.00	0.50	0.47
Karwi ghat	26	8.40	490	218	700	482	8.90	2.40	43.10	0.63	0.56

Table-5
Pollution load at different sampling station of river Mandakini

S.N.	Station	Average flow rat m ³ /s	BOD mg/l	Pollution load Kg/day
1.	Arogyadham	3.231	3.37	940.76
2.	Ramghat	5.647	3.90	1902.81
3.	Karwi ghat	5.728	4.00	1979.60

Table-6
Physiochemical quality of drains May, 2012

Station	Parameters								
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. µmho /cm	DO mg/l	BOD mg/l	COD mg/l
Vaidehi vatika	23	7.40	590	232	822	940	2.60	60	132
Paisuni	25	7.90	666	260	946	1080	1.40	66	136
Sitapur slope	24	7.60	512	215	737	1020	1.20	68	140
Taraunha	25	7.60	710	280	990	1160	4.20	42	108
Karwi bridge	24	7.40	610	260	870	962	2.80	58	122

Table-7
Physiochemical quality of drains June, 2012

Station	Parameters								
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. µmho /cm	DO mg/l	BOD mg/l	COD mg/l
Vaidehi vatika	24	7.70	710	320	1030	1160	2.80	56	122
Paisuni	25	7.80	780	342	1122	1182	2.60	60	128
Sitapur slope	23	7.20	620	280	900	1042	2.50	64	134
Taraunha	23	7.50	690	310	1000	1060	4.80	32	92
Karwi bridge	24	7.50	600	260	860	968	3.50	40	102

Table-8
Physiochemical quality of drains July, 2012

Station	Parameters								
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. µmho /cm	DO mg/l	BOD mg/l	COD mg/l
Vaidehi vatika	24	7.50	762	298	1060	1096	2.80	62	134
Paisuni	25	8.20	792	344	1136	1190	2.40	60	128
Sitapur slope	25	8.00	665	282	947	1012	2.00	68	140
Taraunha	24	8.00	780	320	1100	1134	3.20	52	120
Karwi bridge	23	7.40	542	226	768	882	3.00	64	136

Table-9
Average Physiochemical quality of drains (2012)

Station	Parameters							
	Temp. °C	pH	TDS mg/l	TSS mg/l	TS mg/l	E.C. µmho /cm	DO mg/l	COD mg/l
Vaidehivatika	23.67	7.53	687.33	283.33	970.67	1065.33	2.73	129.33
Paisuni	25.00	7.53	746.00	315.33	1068.00	1150.67	2.13	130.67
Sitapur slope	24.00	7.60	599.00	259.00	861.33	1024.67	1.90	138.00
Taraunha	24.00	7.70	726.67	303.33	1030.00	1118.00	4.07	106.67
Karwi bridge	23.67	7.43	584.00	248.67	832.67	937.33	3.10	120.00

Table-10
Pollution load of selected drain of river Mandakini.

Selected Drains	Flow Rate m ³ /sec.	BOD mg/l.	Pollution load Kg/day
Vaidehi Vatika	0.0019	59.33	9.74
Paisuni	0.0143	62.00	76.60
Sitapur slope	0.0026	66.67	14.98
Taraunha	0.0017	42.00	6.17
Karwi bridge	0.0022	54.00	10.26

Table-11
Primary water quality criteria for various wastewaters as laid down by the Central Pollution Control Board (1999-2000)

S.N.	Characteristics	Standard limits
1.	pH	6.5-8.5
2.	Turbidity (NTU)	10
3.	DO (mg/l)	5
4.	BOD (mg/l)	30
5.	COD (mg/l)	250
6.	EC (µmhos/cm)	1000
7.	TDS(mg/l)	500
8.	TSS(mg/l)	100

Conclusion

From the results of the studies it is concluded that the physico-chemical quality (pH, DO, BOD, COD, Conductivity) of river water found well within the permissible limits of CPCB except TSS. The maximum TSS value was found in the range of 110-218 mg/l. BOD and COD also increase as one proceeded downstream at Arogyadham to Karwighat reach except BOD value 6.8 mg at Karwighat June 2012. The pollution load of river water was found in the range of 940.76-1979.60 Kg/day. Hence, the river water may be supplied for drinking and domestic use after proper treatment. While the quality of drains water was found beyond the permissible limits of CPCB. Physico-chemical qualities of drains water were very poor as these drains carry waste at Paisuni and Sitapur slope. So Paisuni and Sitapur slope were the major source of Pollution as these drains carries the maximum quantity of waste. The pollution load of drains waste water was found in the range of 6.17-76.60 Kg/day. The pollution loads of Paisuni was many time higher in comparison to other drains. So Paisuni drain was the major source of pollution due to joining of many minor nallas. The quality of waste water during study also indicated that river seemed much polluted from Arogyadham to Karwi bridge due to several (small and big) drains joining the river as point pollution sources. Phosphates and nitrate were rather low at all sampling station of river. Their concentrations were observed to be increasing as one proceeded downstream of river. This may cause eutrophication in river.

Recommendation: The recommendation and suggestions is being given on the basis of finding result, the study showed that the physico-chemical quality of river is in D category, therefore proper management requires to check the entry of a large number of drains directly (small and big) in to river Mandakini.

These drains before reaching the river they should be treated or they should be diverted towards other side. Sewage treatment plant should be installed and treated water should be used for agriculture or other uses for domestic purpose except drinking and bathing. These above recommendations and suggestions may be applied to municipal water supplying authorities in order to obtain clean environment and good health.

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