INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 26, No. 2, p. 70-80, 2025
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Assessment of physico-chemical parameters of Gambhiri River in Chittorgarh City of Rajasthan

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Article published on February 05, 2025

Key words: Sustainable, Physico-chemical parameters, Gambhiri River, Chittorgarh

Abstract

Water is vital to life and the environment but over the past few decades, it has been getting worse and worse due to pollution, climate change, and over-extraction. It's really important to look at water quality when the main focus is on sustainable development and keeping humanity at the forefront. A study on the physico-chemical parameters of Gambhiri River, Chittorgarh city of Rajasthan was conducted from January 2022 to December 2022. Six sampling sites were selected and the physico-chemical parameters were determined using standard methods and procedures (IS: 3025; APHA: 4500, 1992). The results revealed that the mean of readings of six sites for various physicho-chemical parameters were, like for water temperature it was (27.10 °C), pH (7.70), Total Dissolved Solids (448.69 mg/l), Turbidity (8.69 NTU), Electric Conductivity (832.97µS/cm), Total Hardness (204.17mg/l), Chloride (92.43mg/l), Alkalinity (214.72mg/l), Nitrate (14.43mg/l), Dissolved Oxygen (6.79mg/l), Biological Oxygen Demand (3.57mg/l), Phosphorus (0.09mg/l) and Sulphate (27.71mg/l). The overall result showed that site (S4), i.e., Keer Khera was a more polluted area and the minimum polluted river water area was recorded at the site (S1), i.e., reserve police line among all the studied sites.

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Introduction

Water is an essential component of life and thus responsible for the healthy survival of all living beings. Rivers are a key source of drinking water and irrigation. However, modern civilization, industrialization, urbanization, and population growth have significantly degraded the quality of surface water. This polluted surface water can negatively impact groundwater, and since water is a crucial part of our ecosystem, any disruption caused by contaminants can have harmful effects on the entire ecosystem (Chauhan *et al.*, 2020).

Pollutants in the water can affect the quality of water and because of this; it can also affect the biological species and human health. Anthropogenic activities like discharges of domestic waste, polluted wastes from the sewage treatment plants, plastic materials, bottles, polythene, disposal of personal care products and household chemicals, improper disposal of car batteries, waste materials from construction activities, mining activities, and pilgrim activities make water polluted and lead to a worsening of the quality of water of the rivers (Heydari and Bidgoli, 2012).

The health of human beings is directly related to water availability and quality. The river basin has long been a major water source for various uses and provides fertile land, which is conducive to the growth of densely populated urban areas because of its favorable conditions (Mouri *et al.*, 2011). In the last few decades, the growing population and the consequent increase in industrial activities have contributed in creating many environmental problems, mainly those related to the conservation of ground and surface water. Pure drinking water is currently accepted as a basic right of human beings. Water helps to improve the circulation of oxygen throughout the body. Insufficient water content in the human body results in severe dehydration, which is often accompanied by seizures, kidney failure, and swelling in the brain. The composition of water changes a lot due to residues. These waste materials produce harmful effects on organisms inhabiting and residing in these areas. This has also impact on the human body as studied by Tiburtius *et al.* (2004).

Freshwater ecosystems are inland water of the world, including lakes, rivers, streams, and wetlands. The study of freshwater ecosystems includes an examination of their physical and chemical composition, the plant, animal, and microbial populations that comprise them, and the relationship among these components (Tundisi and Matsumura-Tundisi, 2003).

A systematic analysis of the relationship between water quality parameters helps to evaluate the water's overall quality, measure the relative concentration of different pollutants in the water, and provide the information needed to implement fast water quality management programs (Dash *et al.*, 2006). Strict monitoring and observation of the water bodies provide important information for the management of the river basin. These quality checks of water can help conserve pure quality water for future generations and species.

The Gambhiri River water is utilized for agriculture, drinking, and other domestic purposes.

The quality of drinking water must be tested at regular intervals since the population can suffer from a range of waterborne illnesses as a result of the usage of polluted drinking water.

The existing basic information on the physico-chemical characteristics of river water will be useful for further ecological assessment and river quality monitoring. In our study, we compared the physico-chemical parameters of water with water quality standards to validate the current water quality condition of the Gambhiri river of Chittorgarh, Rajasthan.

Materials and methods

Location of the study area

Chittorgarh city is located beside a high hill where Chittorgarh fort is situated near the Gambhiri river and between 23˚32'and 25˚13' north latitudes and between 74˚12' and 75˚49' east longitudes in the southeastern part of Rajasthan state (Figs 1, 2&3; Table 1). Chittorgarh is situated between the rivers Berach and Gambhiri and has an average elevation of 394 meters from the sea level. It is located in the southern part of Rajasthan state, and the northwestern part of India (Loth and Panchal, 2023).

Fig. 1. Map showing Chittorgarh District in Rajasthan (India)

Map not on scale, Source: http://surl.li/lovmc

Fig. 2. Satellite view showing Gambhiri river

Water sample collection

The samples were collected from January 2022 to December 2022 from the effluent added into the river. The water samples were collected from 6 sampling sites of Gambhiri river in the Chittorgarh district of Rajasthan, India. The water samples were collected in plastic bottles with a 2-liter capacity, pre-cleaned, and rinsed with the necessary precautions (Fig. 4&5).

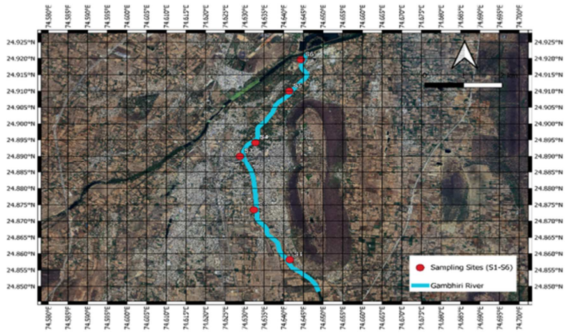

Fig. 3. Map showing sampling sites at Gambhiri river

Table 1. Study site

Site	Site name	Latitude & Longitude	Elevation (From sea level)
S1	Camp reserve police line	24˚51'17" N, 74˚38'38" E,	403m
S2	Mewar girls' college	24˚52'24" N, 74˚37'58" E,	395m
S3	Gambhiri bridge	24˚53'25" N, 74˚37'44" E	392m
S4	Keer Khera	24˚53'39" N, 74˚37'56" E,	392m
S5	Bhoi Khera	24˚54'34"N, 74˚38'30" E	393m
S6	Sangam Mahadev temple	24˚55'14" N, 74˚38'42" E	389m

Fig. 4. Effluent addition at Gambhiri river (Site1)

Fig. 5. Effluent addition at Gambhiri river (Site 4)

Analysis of water parameters

Water temperature: The surface water temperature was recorded with the help of a mercury-in-glass thermometer (˚C) (IS 3025 pt-9, 1984).

pH: The pH of water was determined with the help of a digital pH meter at the sampling site (IS 3025 pt-11, 1983).

Total dissolved solids (TDS): Total dissolved solids (TDS) was determined as per the Indian standard method (IS 3025 pt-16, 1984).

Turbidity: Turbidity was measured using a turbidimeter, which measures the intensity of light scattered by suspended particles in the water (IS: 3025 pt-10, 1984).

Electrical conductivity (EC): This part specifies the procedure for measuring the electrical conductivity of water, which measures the water's ability to conduct electricity, typically using a conductivity meter (IS 3025 pt-14, 1984).

Hardness: This was analyzed using the EDTA method and total hardness was determined by Eriochrome black-T titration (IS: 3025 pt-21, 2009).

Chloride: The sample after neutralization was titrated against standard silver nitrate solution using potassium Chromate as an indicator (IS: 3025 pt-32, 1988).

Alkalinity: This was analyzed by using the following Phenolphthalein indicator method and by sulphuric acid titration (IS: 3025 pt-23, 1986).

Nitrate: The UV spectrophotometric method (APHA 4500-NO_3^-, 1992) was used to measure nitrate concentration by detecting absorbance at 220 nm, with a correction for organic interference at 275 nm. The difference in absorbance was used to calculate nitrate levels in the sample.

Dissolved oxygen (DO): To determine dissolved oxygen (DO) using Winkler's method (IS: 3025 pt-38, 1989).

Biochemical oxygen demand (BOD): To determine Biochemical Oxygen Demand (BOD) using Winkler's method, dissolved oxygen (DO) of a water sample was measured before and after a 5-day incubation period. The difference between the initial and final DO was calculated to measure BOD (IS: 3025 pt-44, 1993).

Phosphorus: The method often involves the use of colorimetric techniques after converting phosphorus to a detectable form, typically through a reaction with molybdate (APHA Method 4500-P, 1992).

Sulphate: A spectrophotometer was used to determine water sulphate through the Turbidity method. Sulphate was precipitated as Barium Sulphate when reacted with Barium Chloride solution. This White precipitate obtained was read on a spectrophotometer at 420 nm along with a series of standard Sulphate solutions (APHA Method 4500-SO_4^{2-}, 1992).

Results and discussion

Results of water quality parameters of Gambhiri river were compared with the standard permissible limit as recommended by the Bureau of India Standards (BIS), Indian Council of Medical Research (ICMR), and World Health Organization (WHO).

To compare water quality parameters of different sites ANOVA was applied. The result showed Non-Significant difference in the water temperature ($F = 0.430$, $p > 0.05$), pH ($F = 1.720$, $p > 0.05$), Hardness ($F= 0.710$, $p > 0.05$), chloride ($F = 0.630$, $p > 0.05$) Alkalinity ($F=1.590$, $p > 0.05$), Nitrate ($F=0.090$, $p > 0.05$), Dissolved oxygen ($F = 0.930$, $p > 0.05$), BOD ($F=1.090$, $p > 0.05$), Sulphate ($F=0.320$, $p > 0.05$) (Table 2, Fig. 6).

Highly significant difference was observed in Total Dissolved Solids (TDS) ($F=3.560$, $p<0.01$) (Table 2), TDS was recorded highest at Keer Khera (Mean = 623.67), which was significantly higher as compared to TDS at other sites, with the lowest at Campus reserve police line, mean=373.67 (Graph: C).

Table 2. Comparison of different water parameters recorded in sample sites

SL	Variable	Mean	SD	F-value	p-value	Result
1	Water temp.	27.10	3.66	0.430	0.827	NS
2	pH	7.70	0.40	1.720	0.143	NS
3	TDS	448.69	178.23	3.560	0.007	**
4	Turbidity	8.69	4.79	4.400	0.002	**
5	EC	832.97	351.70	4.340	0.002	**
6	Hardness	204.17	96.88	0.710	0.619	NS
7	chloride	912.43	51.75	0.630	0.674	NS
8	Alkalinity	214.72	75.00	1.590	0.176	NS
9	Nitrate	14.43	4.89	0.090	0.993	NS
10	DO	6.79	2.21	0.930	0.465	NS
11	BOD	3.57	1.70	1.090	0.374	NS
12	Phosphorus	0.09	0.01	2.370	0.049	*
13	Sulphate	27.71	5.08	0.320	0.899	NS

Note: NS = p > 0.05; * = p < 0.05; ** = p < 0.01; *** = p<0.001

Table 3. Comparing water quality parameters (Average of 6 Sites), with Standard Values

Parameter		Mean	SD	Std. Value	t	p-value	Result
pH		7.70	0.40	7(WHO)	14.71	0.000	***
TDS	ppt	448.69	178.23	500(WHO)	-2.44	0.017	*
Turbidity	NTU	8.69	4.79	5(WHO)	6.54	0.000	***
Chloride	mg/l	92.43	51.75	250(WHO)	-25.84	0.000	***
Alkalinity	mg/l	214.72	75.00	200(WHO)	1.67	0.100	NS
Nitrate	mg/l	14.43	4.89	45(BIS)	-53.08	0.000	***
Sulphate	mg/l	27.71	5.08	200(BIS)	-288.03	0.000	***
Dissolved Oxygen	mg/l	6.79	2.21	8.3	-5.807	0.000	***

Note: NS = p > 0.05; * = p < 0.05; ** = p < 0.01; *** = p<0.001

The average TDS was lower than the standard value (mean = 448.69, std. value = 500, $p < 0.05$) (Table 3). Our observation confirms with the work of Singh *et al.* (2010). Their physico-chemical parameters were assessed from four rivers Imphal, Iril, Thoubal, and Manipur located in Manipur from April 2008 to March 2009.

Boudeffa *et al.* (2020) observed that higher TDS values can be toxic to aquatic life. Total Dissolved Solids in their study ranged from 341-930 mg/l. Higher values of TDS in their study samples might be owing to domestic discharges from urban areas to agricultural and other human activities at and around the river. They suggested that higher TDS values may also be due to the type of soil through which water flows. ANOVA analysis showed a very significant difference in Total Dissolved Solids between the 5 stations.

Highly significant difference in turbidity was also found ($F = 4.40$, $p < 0.01$), turbidity was highest at Keer Khera (mean=13.39), which was significantly higher compared to turbidity of other sites, with the lowest at campus reserve police line, mean=5.94 (Graph: D).

Turbidity was significantly higher as compared to the standard value (Mean = 8.69, std. value = 5, $p < 0.001$) (Table 3). Turbidity is caused by the breakdown of organic matter in water, and suspended substances like clay also contribute to turbidity. Turbidity is also a result of particles that are scattered when solid waste is disposed of.

Khan and Wen (2021) observed the water sampling of Garra River and found to be the most turbid, with turbidity levels ranging from 178 NTU to 1,355 NTU. This turbidity is primarily due to topsoil disturbance from agriculture and other activities like sand mining, as rivers typically flow down from hilly regions. High turbidity is mainly caused by contaminated runoff from industry, agriculture, markets, and roads. Significant spatial variation in turbidity levels was observed between the sampling points. The nature of pollution and the values of pollution parameters may have been influenced by the various tributaries intersecting the Garra river.

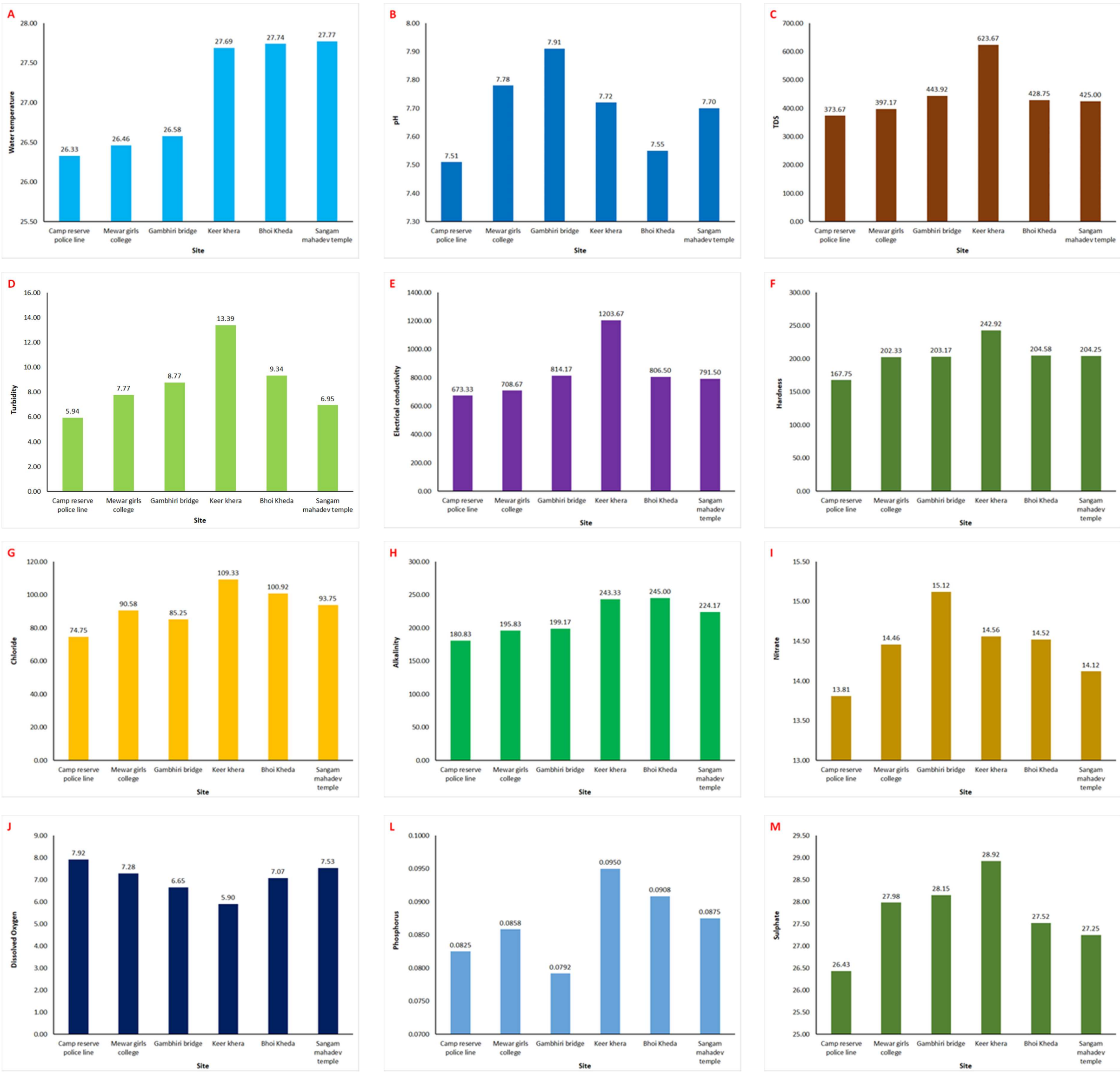

Fig. 6. Different water parameters recorded in sample sites

A highly significant difference in Electrical Conductivity (EC) was found (F= 4.34, $p < 0.01$) (Table 2), EC was highest at Keer Khera (mean = 1203.67), which was significantly higher as compared to EC of other sites, with the lowest at campus reserve police line, mean= 673.33 (Graph: E). Similar observations were also studied by Saxena and Saxena, 2015. EC values are useful indicators of water quality, and a high conductivity level indicates high levels of contamination (WHO, 2011; Pradeep, 1998).

In the study conducted by Boudeffa *et al.* (2020) The EC values ranged from 721-1895 µS/cm. ANOVA analysis showed a very significant difference in electrical conductivity between the 5 stations of their study area.

Atobatele and Ugwumba (2008) observed that electrical conductivity values ranged from 6.80 to 126.40 mV. The significantly higher conductivity observed in Aiba Reservoir during the wet season suggests that external materials carried by streams draining the catchment area significantly influence the reservoir's limnology. The lower conductivity values during the dry season may result from the utilization of these external materials by the reservoir's phytoplankton. High conductivity values are often associated with an increase in the number of polluting particles.

A marginally Significant difference was found in Phosphorus levels ($F=2.370$, $p=0.049$) (Table 2), Phosphorus was highest at Keer Khera (mean = 0·0950), which was significantly higher as compared to other sites. The Phosphorus level of other sites ranged between 0.08 at the Campus Reserve police line, Gambhiri Bridge to 0.09 at Bhoi Khera, Mewar Girl's College, and Sangam Mahadev Temple (Graph: L).

Excess phosphorus in Gambhiri river primarily stems from agricultural runoff (fertilizers and animal waste), urban runoff (lawn fertilizers and sewage), industrial discharges, and soil erosion. According to measurements that have been analyzed, the Gambhiri river water was excess phosphorus at site S 4 (Keer Khera). This leads to eutrophication, where algal blooms deplete oxygen in the water, causing dead zones and biodiversity loss. The resulting harmful algal blooms can produce toxins, degrade water quality, and negatively impact fishing, tourism, and recreation industries.

Edori *et al.* (2015) observed that phosphorus is an essential nutrient for cell growth and function, absorbed into cells and tissues as phosphates. These phosphate compounds help capture energy produced from food and transport it to processes requiring energy, such as movement, replication, and development. Without phosphorus, crucial high-energy compounds like ATPase cannot form effectively.

Non-significant difference was found in Temperature level ($F=0.430$, $p=0.827$) (Table 2), temperature was highest at Sangam Mahadev Temple (mean = 27.77°C) and lowest at campus reserve police line (mean= 26.33°C) (Graph: A). The water temperature (Mean =27.10 °C) (Table 2) is within the accepted international tolerances.

According to Ayoko *et al.* (2007), the value of water does not directly affect human health and well-being, but it can affect the speed of chemical and biological reactions, solubility in water, and taste and smell. Strong unpleasant odors from water may be caused by dissolved gases being released at high temperatures. According to Boudeffa *et al.* (2020), the temperature values ranged from 13.5°C-19°C.

The recorded temperatures are lower compared to the maximum permissible limit (25°C) of the World Health Organization. These measured temperatures reflect the influence of climate and season indicating a thermal balance between water and atmosphere. ANOVA analysis revealed no significant temperature difference between the 5 studied stations.

Non-significant difference was found in Alkalinity (Mean=214.74, std. value =200, $p>0.05$) (Table 3). Similar observations were also reported by Gupta *et al.* (2013); Midha *et al.* (2016). According to IS 10500, the maximum permissible limit of alkalinity for drinking water is 200 mg/L.

Rahman *et al.* (2021) studied that the average total alkalinity (TA) of water samples collected from four points ranged from 165 to 302 mg/L. No significant differences in the total alkalinity values. The increase in total alkalinity levels in urban river water may be attributed to effluents from chemical industries, oil refineries, fertilizer factories, and synthetic mills.

The water body's pH plays an important role in determining the quality of the water. pH was Significantly high (Mean = 7.70, std. value=7, $P < 0.001$) (Table 3) as compared to standard value. The pH range for acceptable drinking water is 6.5 to 8.5.

Singh *et al.* (2010) observed that the pH value of water ranged from 6.5 to 7.9. No significant difference in pH was observed during the study period.

According to Fakayode, (2005) the pH of a water body is very important in the determination of water quality since it affects other chemical reactions such as solubility and metal toxicity.

Chloride was Significantly low as compared to the standard value (mean = 92.43, std. value =250, P <0.001) (Table 3), Chloride was highest at Keer Khera (mean = 109.33), which was significantly higher as compared to Chloride of other sites, with the lowest at campus reserve police line, mean= 74.75 (Graph: G). According to IS 10500, the measured levels are within the permitted range of 250 mg/L.

Rahman *et al.* (2021) studied that the Turag River water showed the highest chloride concentrations ranging from 52.00-132.00 mg/L, there were no significant differences among the chloride concentrations. According to Whitehead *et al.* (2018) possible sources of chloride in the river include chlorinated pesticides and waste discharges from industries and synthetic mills located along the riverside.

A significant indicator of drinking water quality is the nitrate ion concentration because if it exceeds 45 mg/L, it might result in blue babies (methemoglobinemia) in kids. Nitrate was also Significantly low as compared to standard value (mean = 14.43, std. value =45, p<0.001) (Table 3).

Similar results have also been observed by Mitchell *et al.*, 2000. According to Mitchell nitrate concentrations ranged from 0 to 15 mg/L. There were no significant differences in nitrate levels among different sampling sites along the river. Fields with higher nitrogen fertilizer application, especially when applied before planting, had higher nitrate concentrations in the tile drain effluent. An increase in the amount of organic matter in water brings on increased levels of nitrate.

Sulphate was also significantly low as compared to the Standard value (mean =27.71, std. value=200, p<0.001) (Table 3).

Pandey (2014); Saksena *et al.* (2008) observed that biochemicals, anthropogenic sources, industrial processes, etc. are to blame for the increased concentration of sulphate content.

Melaku *et al.* (2007) examined that the sulphate ion concentration in TAR ranged from 4.9 to 65.7 mg/L. The sulphate ion in the river waters may have several sources, that is, dissolution of evaporites such as gypsum, oxidation of sulphides, and atmospheric input.

Finally, Dissolved oxygen (DO) was also significantly low compared to the standard value (mean = 6.79, std. value = 8.3, p<0.001) (Table 3).

Similar trends in dissolved oxygen values have also been reported by Pandey (2014) in River Bicchiya, Rewa, India. A biomarker of bi-oxidisable organic compounds, biological oxygen demand (BOD), was mean =3.57 mg/L. Chauhan *et al.* (2020) studied the Chambal River and it was observed that lower concentration of dissolved oxygen content indicates the mild pollution of river water due to organic waste.

According to measurements that have been analyzed, the Gambhiri river water is moderately polluted with organic wastes in several places.

Conclusion

A study was conducted to evaluate the physico-chemical characteristics of water from the Gambhiri river. The water was collected from nine different places (Camp Reserve Police Line, Mewar Girls' College, Gambhiri Bridge, Keer Khera, and Bhoi Khera) in Chittorgarh City between January 2022 and December 2022. It is concluded that Keer Khera is more polluted and the minimum polluted water was recorded at the reserve police line site among all the study sites. The difference in all physico-chemical parameters at Keer Khera is mainly due to the discharge of household wastewater, Agricultural run-off, and small industries' wastewater into the river. In the present investigation, it was found that the maximum parameters were at the level of pollution except few parameters like pH, and chloride. Thus, the study indicated that the Gambhiri river in Chittorgarh city was highly polluted and unsafe for human use during the sampling time.

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