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Sandeep[1]* and Dharmendra Pratap Singh[2]
[1]Department of Zoology, B.S.A. College, Mathura, Uttar Pradesh, India
[2]Department of Zoology, Agra College, Agra, Uttar Pradesh, India
Email: sandeeptanver880@gmail.com, dr.dpsingh74@gmai.com

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Sandeep[1]* and Dharmendra Pratap Singh[2]

[1]Department of Zoology, B.S.A. College, Mathura, Uttar Pradesh, India

[2]Department of Zoology, Agra College, Agra, Uttar Pradesh, India

Email: sandeeptanver880@gmail.com, *dr.dpsingh74@gmai.com*

ABSTRACT

In recent years, the deterioration of water quality has increasingly made the Chambal River unsuitable for various beneficial uses. Preserving and restoring the river's ecological sustainability is now an urgent necessity. As the Chambal River flows through Kota City, an industrial and educational center in Rajasthan, it is subjected to contamination from various human activities.

Although the river possesses self-purification properties that help reduce pollutants to some extent, the continuous influx of contaminants at a higher rate significantly affects the physicochemical characteristics of the water, rendering it unsafe for intended uses. Given the impact on public health, a physicochemical analysis of the Chambal River's water quality was conducted during the period from 2021 to 2024 in Kota City to assess its suitability for various purposes. The study revealed that during the study period, the overall water quality of the Chambal River in the city area was moderately polluted.

Keywords: *Water quality, River physicochemical parameters, self-purification etc.*

INTRODUCTION

Rivers play a crucial role in shaping and structuring the landscape while influencing the ecological framework of a basin. They are key regulators of the global water cycle and serve as the most dynamic agents of transport within the hydrologic cycle. Communities living along rivers rely on their water for various purposes. However, the quality of surface water is declining due to numerous anthropogenic activities, including industrialization, agriculture, urbanization, transportation, domestic waste disposal, and animal and human excretions.

Variations in river water quality and quantity, influenced by both natural and human-induced factors, have been extensively studied in numerous rivers worldwide. Kuldeep et al. Analysed the Chambal River Quality at Kota Metropolis Through the Drinking Water Quality Index and Irrigation Water Quality Index [1], while Virendra Kushwaha et al. analysed Assessment of Water Quality and Pollution Impact on the Chambal River at Nagda, Madhya Pradesh [2]. Schaefer and Alber focused on nitrogen and phosphorus concentrations in the Altamaha River, Georgia [3], and Rajeev K Chauhan et al. studied the Physico-chemical evaluation of water Quality parameters of Chambal River in Kota [4]. Similarly, Amrita et al. checked the pollution status of some north Indian rivers [5], Kannel et al. analyzed the Bagmati River [6], and thakur et al. examined the groundwater quality of Yamuna basin [7].

Among Indian rivers, those flowing through the Indo-Gangetic Plains have been widely researched. Subramanian documented inconsistent downstream variations in river water chemistry [8], while Singh and Singh, along with Mukherjee et al., explored the physical, chemical, and biological characteristics of the Ganga River [9,10, 16]. Studies have also focused on heavy metal concentrations—such as Cr, Mn, Fe, Co, Ni, Cu, Zn, and Pb—in the sediments of the Ganga basin [11,17-18]. Additionally, extensive research has been conducted on the tributaries of the Ganges, including the Yamuna, Gomti, and Hindon Rivers, covering various physicochemical aspects [12,13].

The present study centers are located on the Chambal River, which flows through the education City, of Kota a major industrial and educational center in the city, of India, serving millions of students. The river is under immense pressure due to encroachments, the discharge of untreated industrial and domestic waste, solid waste dumping, and the illegal diversion

*Author for correspondence

of water. Despite these challenges, limited research has been conducted to establish critical baseline information [14,15]. This paper aims to address this gap by focusing on the present pollution status of the Chambal River, which is determined by analyzing a few physicochemical parameters given in Table 3.

MATERIAL AND METHODS

Two different locations along the Chambal River were selected to study the physicochemical characteristics of river water samples from 2021 to 2024.

Kota district is situated between 24°25' and 25°51' North latitude and 75°31' and 77°26' East longitude, covering a total area of 5,767.97 square kilometers. Kota City lies at the southernmost part of the district, positioned at 25°11' North latitude and 75°51' East longitude, spanning 238.59 square kilometers with an average elevation of 253.30 meters above sea level. The district shares its borders with Sawai Madhopur, Bundi, and Tonk in the northwest, Chittorgarh in the west, Jhalawar in the south, and Baran in the east.

The city experiences an extreme climate, with temperatures ranging from 6°C to 48°C. The average annual rainfall is approximately 880 mm, and humidity fluctuates between 8% and 88% throughout the year.

Kota is a major industrial hub of Rajasthan, known for its historical significance. The city is particularly famous for its coaching institutes that prepare students for national and state-level engineering and medical entrance exams.

Kota is well-connected to major cities across India via a broad-gauge railway network.

Geomorphologically, Kota City is located in the northern part of the Malwa Plateau. The Chambal River, the only perennial river in the region, originates from the hills of western Madhya Pradesh and flows through the district.

Chambal River

The Chambal River, historically known as Charmanyawati, is a major tributary of the Yamuna River. It originates from the Vindhyan ranges at Manpur near Mhow in Indore district, Madhya Pradesh, situated at 22°27' North latitude and 73°20' East longitude, at an elevation of 354 meters above sea level.

The river enters Rajasthan near Chourasigarh, flowing through the districts of Kota, Sawai Madhopur, and Dholpur for a stretch of 376 km before entering Uttar Pradesh, where it eventually merges with the Yamuna River.

Like most rivers in India, the Chambal River is vital to the thousands of communities residing along its banks. Kota City is situated along the river, with the Chambal flowing directly through it. The river's water is extensively utilized for irrigation, drinking, domestic use, and industrial purposes.

Sampling techniques and analysis were used for this purpose, and two locations were selected along the river Chambal in Kota City, Kota. Samples were collected in sterilized polypropylene bottles using the standard procedure of grab or catch as per the APHA (1995) methods in 2021 -2024. Sampling locations and respective sampling codes are shown in Table 1. Physicochemical parameters such as pH, temperature, conductivity, turbidity, total dissolved solids, total hardness, calcium hardness, magnesium hardness, chloride, total alkalinity, ammonia, sulfate, nitrate, fluoride, sodium, potassium, dissolved oxygen, chemical oxygen demand, biological oxygen demand, and iron were selected and estimated quantitatively as per standard methods & procedures of APHA (1995). Details of the analysis methods are summarized in Table -2.

Table 1: Sampling locations on River Chambal in the Kota City Area

S.No	Location	Code
1	Near Chambal Garden	SWS 1
2	Near Kota barrage	SWS 2

Table 2: Parameters and methods employed in the physicochemical examination of water samples

S.No.	**Parameters of water analysis**	**Method used**
1.	Temperature (ºC)	Thermometric
2.	Conductivity (µS/cm)	Potentiometric
3.	Total Dissolved Solids	Gravimetric
4.	Total Hardness (as CaCO3)	Titrimetric
5.	Chloride (as Cl-)	Titrimetric
6.	Nitrate (as NO3-)	Spectrophotometric
7.	Sulphate (as SO4 2-)	Spectrophotometric
8.	Fluoride (as F-)	Ion Selective electrodes
9.	Sodium (as Na+)	Flame Photometric
10.	Potassium (as K+)	Flame Photometric
11.	Iron (as Fe2+)	Spectrophotometric
12.	Total Ammonia (as NH3)	Spectrophotometric
13.	Dissolved Oxygen (as O2)	Titrimetric
14.	Chemical Oxygen Demand (as O2)	Titrimetric
15.	Biochemical Oxygen Demand	Titrimetric
16.	pH	Potentiometric

Table-3: Average values of Physico-chemical parameters of Chambal River water along with Kota City during, the years 2021-24

1	2021 **SWS 1**	2021 **SWS 2**	2022 **SWS 1**	2022 **SWS 2**	2023 **SWS 1**	2023 **SWS 2**	2024 **SWS 1**	2024 **SWS 2**
TDS (mg/L)	200	188	216	197	180	215	240	180
DO (mg/L)	6.1	5.7	5.3	4.9	5.1	4.6	4.3	4.8
PH	8.10	8.25	9.30	8.50	9.3	9.2	8.25	8.40
Turbidity (NTU)	5.2	5.0	4.8	6.9	5.4	5.2	5.1	8.4
BOD (mg/L)	1.2	1.51	3.2	3.0	2.2	8.8	7.2	8.4
Nitrate (mg/L)	10.6	9.7	17.9	23.5	28.5	34.6	28.5	31.5
TP (mg/L)	4.9	4.8	5.0	5.2	4.9	5.0	6.8	7.0
Temperature	30	32	31	32	30	31	31	32
Conductivity (µS/cm)	296	345	310	306	325	330	304	320
Total Hardness (mg/L)	134	142	146	138	140	136	138	144
Chemical Oxygen Demand (mg/L)	9.40	16.4	26.4	28.2	16.4	22.4.	14.6	36.2
Chloride (mg/L)	15.5	18.2	16.2	16.4	14.2	16.4	14.8	18.9
Sulphate (mg/L)	13.4	14.5	22.2	18.6	16.4	15.2	24.2	26.6
Fluoride (mg/L)	0.16	0.22	0.28	0.26	0.42	0.32	0.36	0.44
Sodium (mg/L)	16.2	22.3	24.6	32.4	28.4	16.4	20.4	34.6
Potassium (mg/L)	2.6	3.1	3.2	2.8	2.4	3.4	3.1	3.8
Iron (mg/L)	0.13	0.15	O.16	0.15	0.17	0.17	0.16	0.18
Total Ammonia (mg/L)	0.12	0.16	0.36	0.45	0.65	0.56	0.72	0.75

RESULTS AND DISCUSSION

The physicochemical characteristics of surface water samples collected from Two locations along the Chambal River in Kota City during 2021–2024 are summarized in Table 3.

The pH levels of all analyzed water samples during this period was slightly alkaline, ranging from 8.10 to 9.40 over the four years. The permissible pH range for drinking water is 6.5 to 8.5. River water temperature varied between 30°C and 33°C, while electrical conductance ranged from 296 µS to 345 µS. Neither parameter significantly impacts the suitability of the water for drinking purposes.

Turbidity levels were recorded between 4.8 and 8.4 NTU, mainly due to colloidal particles, suspended materials like clay, and solid waste disposal. Total Dissolved Solids (TDS) ranged from 180 to 240 mg/L.

Total hardness in the study area was found to be between 134 and 144 mg/L. Chloride concentrations, which can give water a salty taste and, at higher levels, cause a laxative effect, ranged from 15.5 to 18.9 mg/L—well within the permissible limit of 250 mg/L, as per IS 10500 standards.

Nitrate concentration is a key parameter in drinking water, as exceeding 45 mg/L can lead blue baby syndrome in infants. In this study, nitrate levels ranged from 10.6 to 34.6 mg/L, with organic pollution contributing to increased levels.

Sulphate levels varied between 13.4 and 26.6 mg/L. Elevated sulphate concentrations, often resulting from biochemical, anthropogenic, and industrial activities, can have a laxative effect on human health.

Fluoride concentrations were within the specified limits, ranging from 0.16 to 0.44 mg/L. Sodium levels in the samples varied between 16.2 and 34.6 mg/L, with slightly elevated concentrations likely caused by untreated industrial and domestic waste discharge.

Potassium levels, typically low in natural water but influenced by pollution, ranged from 2.6 to 3.8 mg/L. Iron concentrations in the samples were recorded between 0.13 and 0.18 mg/L. Although natural iron levels in water are usually low, contamination in the river may be linked to industrial effluents and automobile activities along the riverbanks. The presence of ammonia in water indicates pollution from untreated domestic, industrial, and sewage effluents. Ammonia levels in the samples ranged from 0.12 to 0.75 mg/L, suggesting moderate pollution.

Dissolved oxygen (DO) levels varied between 4.30 and 6.10 mg/L, with lower values indicating mild organic pollution. Chemical Oxygen Demand (COD) values ranged from 9.40 to 36.20 mg/L, with higher levels at some locations signaling contamination by chemically oxidizable organic and inorganic substances. Biological Oxygen Demand (BOD), a key indicator of biodegradable organic matter, ranged from 1.20 to 8.20 mg/L, confirming moderate pollution due to organic waste.

CONCLUSION

Analyzed data clearly reveals that at some places river water is highly polluted but overall river water along the Kota City area is moderately polluted by organic as well as inorganic substances. This happened due to the disposal of untreated domestic and sewerage effluents in the river directly through so many drains from city areas. It was also observed at some locations solid waste also dumped in rivers making conditions worse. To sustain the river water quality for an intended purpose, the diversion of local drains that carry effluents from various sources from the city area has to be made possible. Presently two STPs are in operation, few more STPs have to be installed for this holy purpose.

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