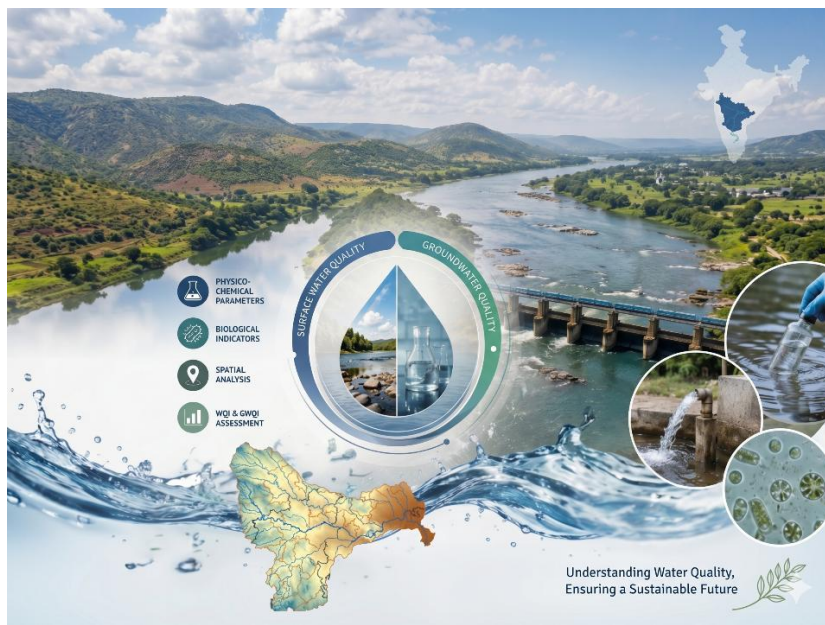




**National River Conservation Directorate**  
Ministry of Jal Shakti,  
Department of Water Resources,  
River Development & Ganga Rejuvenation  
Government of India

# Physio-chemical and Biological Profile of Krishna River Basin



April 2026



© cKrishna, cGanga and NRCD, 2025

## **Back of cover page**

# Physio-chemical and Biological Profile of Krishna River Basin



© cKrishna, cGanga and NRCD, 2025

## **National River Conservation Directorate (NRC D)**

The National River Conservation Directorate, functioning under the Department of Water Resources, River Development & Ganga Rejuvenation, and Ministry of Jal Shakti providing financial assistance to the State Government for conservation of rivers under the Centrally Sponsored Schemes of ‘National River Conservation Plan (NRCP)’. National River Conservation Plan to the State Governments/ local bodies to set up infrastructure for pollution abatement of rivers in identified polluted river stretches based on proposals received from the State Governments/ local bodies.

[www.nrcd.nic.in](http://www.nrcd.nic.in)

## **Centres for Krishna River Basin Management Studies (cKrishna)**

The Centres for Krishna River Basin Management Studies (cKrishna) is a Brain Trust dedicated to River Science and River Basin Management. Established in 2024 by NIT Warangal and NIT Surathkal, under the supervision of cGanga at IIT Kanpur, the center serves as a knowledge wing of the National River Conservation Directorate (NRC D). cKrishna is committed to restoring and conserving the Krishna River and its resources through the collation of information and knowledge, research and development, planning, monitoring, education, advocacy, and stakeholder engagement.

[www.ckrishna.org](http://www.ckrishna.org)

## **Centre for Ganga River Basin Management and Studies (cGanga)**

cGanga is a think tank formed under the aegis of NMCG, and one of its stated objectives is to make India a world leader in river and water science. The Centre is headquartered at IIT Kanpur and has representation from most leading science and technological institutes of the country. cGanga’s mandate is to serve as think-tank in implementation and dynamic evolution of Ganga River Basin Management Plan (GRBMP) prepared by the Consortium of 7 IITs. In addition to this, it is also responsible for introducing new technologies, innovations, and solutions into India.

[www.cganga.org](http://www.cganga.org)

## **Acknowledgment**

This report is a comprehensive outcome of the project jointly executed by NIT Warangal (Lead Institute) and NIT Surathkal (Fellow Institute) under the supervision of cGanga at IIT Kanpur. It was submitted to the National River Conservation Directorate (NRC D) in 2024. We gratefully acknowledge the individuals who provided information and photographs for this report.

## **Team Members**

N V Umamahesh, cKrishna, NITW	B. Manu, cKrishna, NITK
M Chandrasekhar, cKrishna, NITW	
K Venkata Reddy, cKrishna, NITW	Vinod Tare, cGanga, IITK
P Hari Prasada Reddy, cKrishna, NITW	
Ajey Patel, cKrishna, NITW	
G Gowtham, cKrishna, NITW	
Prasanta Majee, cKrishna, NITW	
Eswar Sai Buri, cKrishna, NITW	
Kandula Srikanth, cKrishna, NITW	
D Ravi Teja, cKrishna, NITW	
Guguloth Sai, cKrishna, NITW	
G V Sai Krishna, cKrishna, NITW	
S Chirasmayee, cKrishna, NITW	

## Preface

In an era of unprecedented environmental change, understanding our rivers and their ecosystems has never been more critical. This report aims to provide a comprehensive overview of our rivers, highlighting their importance, current health, and the challenges they face. As we explore the various facets of river systems, we aim to equip readers with the knowledge necessary to appreciate and protect these vital waterways.

Throughout the following pages, you will find an in-depth analysis of the principles and practices that support healthy river ecosystems. Our team of experts has meticulously compiled data, case studies, and testimonials to illustrate the significant impact of rivers on both natural environments and human communities. By sharing these insights, we hope to inspire and empower our readers to engage in river conservation efforts.

This report is not merely a collection of statistics and theories; it is a call to action. We urge all stakeholders to recognize the value of our rivers and to take proactive steps to ensure their preservation. Whether you are an environmental professional, a policy maker, or simply someone who cares about our planet, this guide is designed to support you in your efforts to protect our rivers.

We extend our heartfelt gratitude to the numerous contributors who have generously shared their stories and expertise. Their invaluable input has enriched this report, making it a beacon of knowledge and a practical resource for all who read it. It is our hope that this report will serve as a catalyst for positive environmental action, fostering a culture of stewardship that benefits both current and future generations.

As you delve into this overview of our rivers, we invite you to embrace the opportunities and challenges that lie ahead. Together, we can ensure that our rivers continue to thrive and sustain life for generations to come.

Prof. N V Umamahesh  
Centres for Krishna River Basin  
Management Studies (cKrishna)  
NIT Warangal (Lead Institute), NIT Surathkal (Fellow Institute)

## **Back of Preface/Blank Page**

Blank/Continuation of Preface

## Contents

<b>Preface.....</b>	<b>v</b>
<b>List of Figures.....</b>	<b>ix</b>
<b>List of Tables .....</b>	<b>xii</b>
<b>Abbreviations and Acronyms .....</b>	<b>xiv</b>
<b>1. Introduction .....</b>	<b>1</b>
<b>2. Study Area and Monitoring Network.....</b>	<b>2</b>
<b>3. Surface Water Quality of Krishna River Basin.....</b>	<b>3</b>
3.1 Monitoring Stations and Frequency:.....	3
3.2 Key Physico-Chemical and Biological Parameters:.....	7
3.3 Water Quality Standards and Criteria .....	9
3.4 Spatial and Temporal Trends .....	10
3.4.1 Water Quality in Krishna River.....	10
3.4.2 Water Quality in Tributaries of Krishna River.....	18
3.5 Water Quality Index .....	24
<b>4. Groundwater Quality of Krishna River Basin.....</b>	<b>29</b>
4.1 Monitoring Details and Frequency .....	29
4.2 Key Physico-Chemical Parameters .....	30
4.2.1 pH .....	31
4.2.2 Electrical Conductivity (EC) .....	32
4.2.3 Bicarbonates ( $\text{HCO}_3^-$ ) .....	34
4.2.4 Chlorides ( $\text{Cl}^-$ ) .....	35
4.2.5 Sulphates ( $\text{SO}_4^{2-}$ ) .....	37
4.2.6 Nitrates ( $\text{NO}_3^-$ ).....	39
4.2.7 Total Hardness.....	41
4.2.8 Calcium ( $\text{Ca}^{2+}$ ).....	42
4.2.9 Magnesium ( $\text{Mg}^{2+}$ ) .....	44
4.2.10 Sodium ( $\text{Na}^+$ ).....	46
4.2.11 Potassium ( $\text{K}^+$ ).....	47
4.2.12 Fluorides ( $\text{F}^-$ ) .....	49
4.2.13 Total Dissolved Solids (TDS).....	51
4.3 Groundwater Quality Index (GWQI).....	52
<b>5. Summary and Recommendations .....</b>	<b>55</b>

5.1	Summary.....	55
5.2	Recommendations.....	57
<b>References:.....</b>		<b>59</b>

## List of Figures

Figure 1 Monitoring stations of the Krishna River and its tributaries .....	4
Figure 2 Spatial and temporal variation of temperature at different monitoring stations during 2018-2023 .....	11
Figure 3 Spatial and temporal variation of pH at different monitoring stations during 2018-2023.....	12
Figure 4 Spatial and temporal variation of pH at different monitoring stations during 2018-2023.....	13
Figure 5 Spatial and temporal variation of dissolved oxygen at different monitoring stations during 2018-2023.....	14
Figure 6 Spatial and temporal variation of biochemical oxygen demand at different monitoring stations during 2018-2023.....	15
Figure 7 Spatial and temporal variation of nitrate at different monitoring stations during 2018-2023.....	16
Figure 8 Spatial and temporal variation of fecal coliforms at different monitoring stations during 2018-2023.....	17
Figure 9 Spatial and temporal variation of total coliforms at different monitoring stations during 2018-2023 .....	18
Figure 10 Spatial distribution River Water Quality Index during 2023 .....	27
Figure 11 Spatial distribution of Water Quality Index (WQI) in the Krishna River Basin during 2018-2023: (a) 2018, (b) 2019, (c) 2020, (d) 2021, and (e) 2022.....	28
Figure 12 Spatial distribution of pH in Krishna River Basin (2023).....	32
Figure 13 Spatial distribution of Electrical Conductivity in Krishna River Basin (2023).....	33
Figure 14 Spatial distribution of Bicarbonates in Krishna River Basin (2023).....	34
Figure 15 Spatial distribution of Chlorides in Krishna River Basin (2023) .....	36
Figure 16 Spatial distribution of Sulphates in Krishna River Basin (2023) .....	38
Figure 17 Spatial distribution of Nitrates in Krishna River Basin (2023).....	40
Figure 18 Spatial distribution of Total Hardness in Krishna River Basin (2023) .....	41
Figure 19 Spatial distribution of Calcium in Krishna River Basin (2023) .....	43
Figure 20 Spatial distribution of Magnesium in Krishna River Basin (2023).....	45
Figure 21 Spatial distribution of Sodium in Krishna River Basin (2023) .....	47
Figure 22 Spatial distribution of Potassium in Krishna River Basin (2023) .....	48

Figure 23 Spatial distribution of Fluorides in Krishna River Basin (2023).....	50
Figure 24 Spatial distribution of Total Dissolved Solids in Krishna River Basin (2019) .....	52
Figure 25 Spatial distribution of GWQI in Krishna River Basin during 2019 .....	53
Figure 26 Spatial distribution of GWQI in Krishna River Basin during 2023 .....	54
Figure 27 Spatial distribution of groundwater quality parameters during 2019 .....	60
Figure 28 Spatial distribution of groundwater quality parameters during 2019 .....	61
Figure 29 Spatial distribution of groundwater quality parameters during 2022 .....	62
Figure 30 Spatial distribution of groundwater quality parameters during 2022 .....	63

**Continuation of Figures/Blank Page**

## List of Tables

Table 1 The monitoring stations along the Krishna River with latitude and longitude points ..	4
Table 2 Monitoring Stations of the Bhima River with Corresponding Latitude and Longitude Coordinates. ....	5
Table 3 Monitoring stations of the Tungabhadra River with corresponding latitude and longitude coordinates. ....	6
Table 4 Monitoring stations of the Panchaganga River with corresponding latitude and longitude coordinates. ....	6
Table 5 Monitoring stations of Malaprabha River with corresponding with latitude and longitude coordinates. ....	6
Table 6 Monitoring stations of Bhadra River with corresponding with latitude and longitude coordinates. ....	7
Table 7 Monitoring stations of Musi River with corresponding with latitude and longitude coordinates. ....	7
Table 8 Drinking Water quality standards as per BIS IS 10500: 2012.....	9
Table 9 Water quality criteria according to CPCB Guidelines.....	10
Table 10 Statistics of groundwater quality parameters from 2019 to 2023.....	31

**Continuation of Tables/Blank Page**

## Abbreviations and Acronyms

BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
Ca <sup>2+</sup>	Calcium
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
DO	Dissolved Oxygen
EC	Electrical Conductivity
F <sup>-</sup>	Fluoride
GIS	Geographic Information System
GWQI	Groundwater Quality Index
HCO <sub>3</sub> <sup>-</sup>	Bicarbonate
K <sup>+</sup>	Potassium
Mg <sup>2+</sup>	Magnesium
Na <sup>+</sup>	Sodium
NO <sub>3</sub> <sup>-</sup>	Nitrate
NRCD	National River Conservation Directorate
Ph	Potential of Hydrogen
SO <sub>4</sub> <sup>2-</sup>	Sulfate
TDS	Total Dissolved Solids
TH	Total Hardness
WQI	Water Quality Index



# 1. Introduction

The Krishna River Basin is one of the major river basins of peninsular India and plays an important role in supporting domestic, agricultural, industrial, and ecological water demands. The Krishna River originates from the Western Ghats near Mahabaleshwar in Maharashtra and flows eastward for nearly 1,400 km before draining into the Bay of Bengal. The basin extends across the states of Maharashtra, Karnataka, Telangana, and Andhra Pradesh, covering regions with diverse climatic conditions, geology, land use, and water availability.

In recent decades, the water resources of the Krishna River Basin have been subjected to increasing stress due to rapid population growth, urbanization, agricultural intensification, industrial development, and expanding water demand. Excessive dependence on both surface water and groundwater resources has resulted in declining water availability and deterioration of water quality in several parts of the basin. Untreated or partially treated domestic sewage, industrial effluents, and agricultural runoff containing fertilizers and pesticides are among the major sources contributing to water pollution within the basin.

Surface water quality in the Krishna River and its tributaries is influenced by both natural processes and anthropogenic activities. Geological characteristics, rainfall variability, river flow conditions, and seasonal changes affect the hydrochemical characteristics of river water, while urban discharge, industrial activities, and agricultural runoff further influence water quality. Several stretches of the river system, particularly near urban and downstream regions, show signs of water quality deterioration characterized by elevated organic pollution, nutrient enrichment, and microbial contamination.

Groundwater is an important source of drinking and irrigation water in the Krishna River Basin, particularly in rural and semi-arid regions where dependence on groundwater is relatively high. Groundwater quality is mainly controlled by lithology, aquifer characteristics, recharge conditions, groundwater residence time, and anthropogenic influences. In different parts of the basin, groundwater quality problems related to salinity, hardness, nitrate, fluoride, and dissolved ions have been reported. Long-term groundwater quality monitoring data generated by the Central Ground Water Board (CGWB) provide valuable information for understanding the spatial and temporal variation of groundwater quality across the basin.

Assessment of physico-chemical and biological parameters is essential for understanding the overall condition of water resources. Physico-chemical parameters provide information

regarding the chemical characteristics and suitability of water for different uses, whereas biological indicators help in evaluating microbial contamination and ecological health of aquatic systems. Integrated assessment of these parameters is therefore important for effective river basin management and sustainable utilization of water resources. The present report focuses on the assessment of the physico-chemical and biological profile of the Krishna River Basin, with emphasis on both surface water and groundwater quality. Surface water quality assessment was carried out using monitoring data obtained from the Central Pollution Control Board (CPCB), while groundwater quality assessment was performed using data collected from the Central Ground Water Board (CGWB) for the period 2019-2023. Spatial and temporal analyses were carried out to identify major water quality issues and critical pollution hotspots within the basin. The outcomes of the study are expected to support scientific planning and sustainable management of water resources in the Krishna River Basin.

## **2. Study Area and Monitoring Network**

The Krishna River Basin comprises diverse hydrological, geological, climatic, and land-use conditions that strongly influence both surface water and groundwater quality across the basin. The river system includes several major tributaries such as the Bhima, Tungabhadra, Panchaganga, Malaprabha, Bhadra, and Musi rivers, which contribute significantly to the hydrology and water quality characteristics of the basin. Variations in rainfall, geology, urbanization, agricultural activities, and industrial development across different regions result in considerable spatial variability in water quality conditions.

The present study utilizes secondary water quality data collected from national monitoring agencies for the assessment of both surface water and groundwater quality in the Krishna River Basin during 2019-2023. Surface water quality data were obtained from the Central Pollution Control Board (CPCB), while groundwater quality data were collected from the Central Ground Water Board (CGWB). The surface water monitoring network consists of stations located along the main course of the Krishna River and its major tributaries covering upstream, midstream, and downstream stretches. Monitoring stations are situated near urban centres, industrial regions, confluence points, reservoirs, bridges, and water abstraction locations to capture the influence of natural processes and anthropogenic activities on river water quality. Most of the surface water monitoring stations are monitored on a monthly basis for major physico-chemical and biological parameters. The groundwater monitoring network includes observation wells distributed across different hydrogeological settings of the basin representing

major aquifer systems under varying geological and land-use conditions. Groundwater quality assessment was carried out using data from 856 monitoring locations in 2019, 89 locations in 2020, 112 locations in 2021, 1243 locations in 2022, and 1284 locations in 2023. The variation in the number of monitoring locations among different years is mainly associated with monitoring coverage and availability of data.

The monitored parameters include pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), total hardness (TH), calcium ( $\text{Ca}^{2+}$ ), magnesium ( $\text{Mg}^{2+}$ ), sodium ( $\text{Na}^+$ ), potassium ( $\text{K}^+$ ), bicarbonate ( $\text{HCO}_3^-$ ), chloride ( $\text{Cl}^-$ ), sulfate ( $\text{SO}_4^{2-}$ ), nitrate ( $\text{NO}_3^-$ ), and fluoride ( $\text{F}^-$ ), faecal coliforms, and total coliforms. Spatial analysis and GIS-based mapping were carried out to evaluate regional water quality variations and identify critical pollution hotspots within the basin. In addition, Water Quality Index (WQI) and Groundwater Quality Index (GWQI) analyses were performed to assess the overall suitability of surface water and groundwater for drinking and other uses.

### **3. Surface Water Quality of Krishna River Basin**

#### **3.1 Monitoring Stations and Frequency:**

In this study, the surface water quality assessment in the Krishna River basin was carried out employing the data acquired from the Central Pollution Control Board (CPCB). Overall, 68 monitoring stations were used for entire course of the river from source to mouth and important tributaries were also considered. Apart from the main river, the analysis included six significant tributaries: the Bhima River, Tungabhadra River, Panchaganga River, Malaprabha River, Bhadra River, and Musi River. The monitoring stations along the Krishna River and its tributaries are illustrated in Figure 1.

Further to this, among the tributaries, the Bhima and Tungabhadra rivers have higher density of monitoring stations due to their large catchment areas and heavy anthropogenic pressures. Likewise, the Musi River, which passes through heavily urbanized areas, is under intense monitoring for high pollution levels. In other words, tributaries such as the Panchaganga, Malaprabha and Bhadra rivers are added to capture important regional inflows and their integrated impact on the Krishna River system. The selection of monitored stations depends on hydrological and environmental considerations. In particular, stations are located at upstream and downstream of major hydraulic structures and confluences, urban and industrial areas, road crossings, and drinking water abstraction points. In addition, the stations, which are

given a unique station code and latitudinal and longitudinal coordinates, are spread over four states - Maharashtra, Karnataka, Telangana and Andhra Pradesh. The monitoring stations along the Krishna River are presented in Table 1, while the monitoring stations located on its tributaries Bhima River, Tungabhadra River, Panchaganga River, Malaprabha River, Bhadra River, and Musi River-along with their respective latitude and longitude coordinates, are provided in Table 2 to 7.

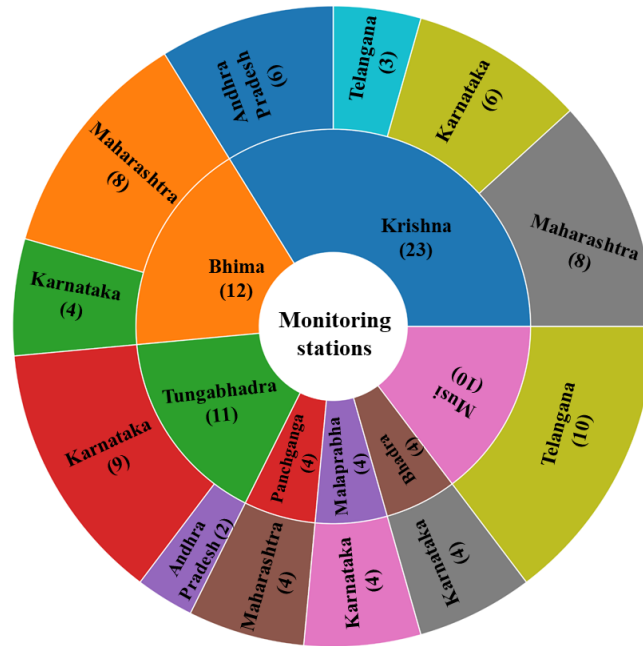


Figure 1 Monitoring stations of the Krishna River and its tributaries

Table 1 The monitoring stations along the Krishna River with latitude and longitude points

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude
1	1153	Krishna River at Rajapur Weir, Village-Rajapur, Taluka-Shirol, District-Kolhapur.	Maharashtra	Monthly	16.6301	74.6639
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.2953	74.1888
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707

10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213
11	1889	Krishna-Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566
14	2781	Krishna at D/S of Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kunool	Andhra Pradesh	Monthly	16.0019	78.365
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.3388	77.6102
18	1465	Krishna at Wadapally after Confl. with R. Musi(Shifted From 1220)	Telangana	Monthly	16.6947	79.6899
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.8019	80.1296
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.5826	80.3435
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.4925	80.6408
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.0879	78.8902
23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near Avanigadda(V), Krishna District	Andhra Pradesh	Monthly	16.0001	81.0791

*Table 2 Monitoring Stations of the Bhima River with Corresponding Latitude and Longitude Coordinates.*

S.no	Station codes	Station names	States	Frequency	Latitude	longitude
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Monthly	18.481871	73.829569
2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur,Pune	Maharashtra	Monthly	18.645719	74.056442
3	1190	Bhima at Pune, D/S Of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Monthly	18.54325	73.885036
4	1191	Bhima at Pargaon (After Confl.with Mula Mutha),Pargaon, Daund, Pune	Maharashtra	Monthly	18.560303	74.37332
5	1192	Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Monthly	18.464553	74.583576
6	1188	Bhima at Narsingpur, (D/S Af.Confl.with R.Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Monthly	17.985845	75.116249
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Monthly	17.703734	75.544604
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Monthly	17.179219	76.566603
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Monthly	17.069328	76.794283
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Monthly	16.7341	77.130744

11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Monthly	17.043481	76.814478
12	2656	Bhima River-Backwater of Ujani Dam near Raw water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Monthly	18.202061	75.088989

*Table 3 Monitoring stations of the Tungabhadra River with corresponding latitude and longitude coordinates.*

S.no	Station codes	Station names	States	Frequency	Latitude	Longitude
1	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Monthly	14.3254	75.7711
2	29	Tungabhadra at Ullanur	Karnataka	Monthly	15.4948	76.6924
3	38	Tungabhadra at Honnali Bridge	Karnataka	Monthly	14.2361	75.6594
4	2767	Tungabhadra at U/S of Hpf,	Karnataka	Monthly	14.5143	75.7857
5	2768	Tungabhadra at D/S of Hpf,	Karnataka	Monthly	14.5143	75.7857
6	2769	Tungabhadra at Jackwell Point,	Karnataka	Monthly	14.5265	75.7961
7	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Monthly	14.5158	75.7979
8	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Monthly	15.4123	76.5863
9	2766	Tungabhadra at New Bridge,	Karnataka	Monthly	14.5143	75.7857
10	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Monthly	15.8483	78.0349
11	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Monthly	15.9445	77.4197

*Table 4 Monitoring stations of the Panchaganga River with corresponding latitude and longitude coordinates.*

S.no	Station codes	Station names	States	Frequency	Latitude	Longitude
1	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Maharashtra	Monthly	16.7462	74.4457
2	2163	Panchaganga River at Shirol near Shirol Intake Well, Kolhapur	Maharashtra	Monthly	16.7215	74.5948
3	1904	Panchaganga U/S of Kolhapur town, Balinga, Karvir, Kolhapur	Maharashtra	Monthly	16.6885	74.1695
4	1905	Panchaganga D/S of Kolhapur town, Uchegaon, Kolhapur	Maharashtra	Monthly	16.6955	74.275

*Table 5 Monitoring stations of Malaprabha River with corresponding with latitude and longitude coordinates.*

S.no	Station codes	Station names	States	Frequency	Latitude	Longitude
1	1187	Malaprabha at D/S of Khanapur Village,	Karnataka	Monthly	15.6334	74.5103
2	1164	Malaprabha at Water Abstr. Pt. to Hubli, Dharwar	Karnataka	Monthly	15.798	75.1915
3	1186	Malaprabha at D/S of Aihole Town,	Karnataka	Monthly	16.0093	75.878

4	2764	Malaprabha at Badami Bridge,	Karnataka	Monthly	15.8757	75.7223
---	------	------------------------------	-----------	---------	---------	---------

*Table 6 Monitoring stations of Bhadra River with corresponding with latitude and longitude coordinates.*

S.no	Station codes	Station names	States	Frequency	Latitude	Longitude
1	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Monthly	13.8323	75.7132
2	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Monthly	13.9893	75.6837
3	2765	Bhadra At U/S Of Mpm,	Karnataka	Monthly	13.8126	75.7163
4	2771	Bhadra At U/S Of Kiocl,	Karnataka	Monthly	13.2128	75.2342

*Table 7 Monitoring stations of Musi River with corresponding with latitude and longitude coordinates.*

S.no	Station codes	Station names	States	Frequency	Latitude	Longitude
1	4253	Musi Sample at Bapughat Sangam U/S of Musi	Telangana	Monthly	17.3718	78.4124
2	4656	River Musi at Moosarambagh Bridge, Hyderabad	Telangana	Monthly	17.3795	78.5168
3	2339	River Musi at Nagole, Rangareddy	Telangana	Monthly	17.3827	78.5578
4	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Monthly	17.3856	78.5611
5	4660	River Musi at Peerajadiguda	Telangana	Monthly	17.3831	78.639
6	1173	Musi D/S at Pratapsingaram, Hyderabad	Telangana	Monthly	17.3701	78.4698
7	4657	River Musi at Pillapalli	Telangana	Monthly	17.3852	78.7376
8	4254	River Musi Sample at Rudravelly Bridge	Telangana	Monthly	17.4068	78.7863
9	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Monthly	17.151	79.5443
10	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Monthly	17.2476	79.492

### 3.2 Key Physico-Chemical and Biological Parameters:

In this project, there are a total of eight key physical, chemical and biological parameters of the Krishna River: temperature, pH, Electrical Conductivity, Dissolved oxygen, Biochemical oxygen demand, Nitrate, Faecal coliforms and Total coliforms were included for the analysis to assess the Krishna River water quality (Shah et al., 2017).

#### a) Temperature:

Temperature is considered the warmness or coldness of a river and it affects the speed of chemical and biological reactions. Warmer temperatures may reduce the amount of oxygen that can dissolve in the water, which can be stressful for aquatic life. In addition, abrupt temperature fluctuations may be a sign of pollution from the waste of industries or from thermal power-generating station.

**b) pH:**

pH is defined as the concentration of  $H^+$  ions in aqueous solution and is used as an indicator to measure acidity and alkalinity of water on a 0-14 scale. The variation in the pH is indicative of contamination by agricultural and industrial effluents as well as domestic sewage. A higher pH may be detrimental to fish and other aquatic animals and alter the ecological balance (Avvanavar and Shrihari 2008).

**c) Electrical Conductivity:**

Electrical Conductivity is a measure of water's ability to conduct electricity and is dependent on the presence of dissolved salts and other chemicals in the water. An increase in the concentration of dissolved substances, implied by higher conductivity values, may be attributed to the discharge of industrial effluent or domestic sewage and run-off from agricultural fields (Sawyer et al. 1994; Leo and Dekkar 2000).

**d) Dissolved Oxygen:**

Dissolved oxygen refers to the amount of oxygen that is available in water, which is necessary for aquatic life, and is influenced by the physical and chemical nature of water body along with water flow rate. High oxygen levels in the water could indicate a healthy environment for aquatic life, while lower levels may represent contamination with organic matter, which can kill fish and other species (Sawyer et al. 1994; Leo and Dekkar 2000; Burden et al. 2002; De 2003).

**e) Biochemical Oxygen Demand:**

Biochemical oxygen demand (BOD) is defined as the amount of oxygen required by microorganisms to decompose organic matter in water. In the Krishna River, elevated BOD levels indicate a significant degree of organic pollution, typically stemming from sewage or waste disposal. This increase in BOD results in a reduction of dissolved oxygen (DO) levels, which adversely impacts aquatic life and the overall quality of the water (Deq 2003).

**f) Nitrate:**

Nitrite is a chemical compound that is naturally present in organic matter and is a component of fertilizers. High nitrate concentrations are typically the result of sewage and animal waste discharge. High concentrations of nitrate may also contribute to the

eutrophication of water bodies, potentially promoting the growth of algae and aquatic plants, decreasing oxygen levels in the water and threatening aquatic ecosystems.

**g) Fecal Coliforms:**

Fecal coliforms are bacteria that naturally live in the bowels of humans and other animals. Their presence is a strong indicator of animal waste or sewage contamination. When water is contaminated with high levels of fecal coliforms, it is likely to contain harmful pathogens and is unsafe to drink, swim in, or use for household purposes.

**h) Total Coliforms:**

There are many species of bacteria within the total coliforms. They are commonly present in soil, faeces and other solids. A high coliform count means that the water is unsafe for consumption, and it's also an indicator used to gauge the general cleanliness of the river. Availability of the potential feeds to microorganisms.

**3.3 Water Quality Standards and Criteria**

The Bureau of Indian Standards (BIS) has prescribed down the drinking water standards, IS 10500:2012, to ascertain the safety of water for human use. The standard defines both acceptable and permissible limits for different physico-chemical and biological parameters. The current work is based on an assessment of water quality using drinking water standards of BIS and surface water quality classification guidelines of Central Pollution Control Board (CPCB). BIS standards are shown in Table 8. The CPCB has defined five water quality categories based on various water quality parameters and their intended uses (A to E) (CPCB) in Table 9.

*Table 8 Drinking Water quality standards as per BIS IS 10500:2012.*

<b>Parameters</b>	<b>Acceptable Limit</b>	<b>Permissible Limit in Absence of an Alternate Source</b>	<b>Unit</b>
Temperature	No standard prescribed	No relaxation	°c
Dissolved oxygen	6	5	mg/L
pH	6.5-8.5	No relaxation	-
Conductivity	300	1500	mg/L
Biochemical Oxygen demand	2	3	mg/L
Nitrate (No3)	45	No relaxation	mg/L

Faecal coliforms	Shall not be detectable in any 100 mL sample	No relaxation	(MPN/100mL)
Total coliforms	Shall not be detectable in any 100 mL sample	No relaxation	(MPN/100mL)

*Source: Bureau of Indian Standards IS 10500:2012 and CPCB guidelines.*

*Table 9 Water Quality Criteria according to CPCB Guidelines*

<b>Best-Use Class</b>	<b>Criteria</b>
A: Drinking Water Source without conventional treatment, but after disinfection	Total Coliforms $\leq$ 50 MPN/100mL, pH 6.5-8.5, DO $\geq$ 6 mg/L, BOD $\leq$ 2 mg/L
B: Outdoor bathing (Organized)	Total Coliforms $\leq$ 500 MPN/100mL, pH 6.5-8.5, DO $\geq$ 5 mg/L, BOD $\leq$ 3 mg/L
C: Drinking water source after conventional treatment and disinfection	Total Coliforms $\leq$ 5000 MPN/100ml, pH 6-9, DO $\geq$ 4 mg/L, BOD $\leq$ 3 mg/L
D: Propagation of Wildlife and Fisheries	pH 6.5-8.5, DO $\geq$ 4 mg/L
E: Irrigation, Industrial Cooling, Controlled Waste Disposal	pH 6.0-8.5, EC $\leq$ 2250 $\mu$ S/cm, Sodium Absorption Ratio $\leq$ 26

*Source: <https://cpcb.nic.in/water-quality-criteria>*

### 3.4 Spatial and Temporal Trends

An examination of the multi-year dataset between 2018 and 2023 from the Central Pollution Control Board for the spatial and temporal assessment of the Krishna River revealed heterogeneity driven by both natural processes and anthropogenic influences (CPCB).

#### 3.4.1 Water Quality in Krishna River

##### i. Temperature:

The temperature of the Krishna River showed good spatial and temporal variation, with the minimum and maximum being around 18.05°C and 32.50°C, respectively, during the study period. Station 2781, located downstream of Alamatti Dam, recorded the highest temperature of approximately 32.50°C in 2018, while Station 1181 consistently observed maximum temperatures of around 30°C during several years. These elevated temperatures may be attributed to shallow flow conditions, reduced shading, and increased solar radiation. In contrast, lower temperatures were observed at Stations 37 and 1465, which were recording approximately 18.05°C in 2023 and ranging between 19°C and 21°C. The relatively lower temperatures at these locations may be associated with groundwater upwelling and localized cooling effects. Overall, most monitoring stations exhibited temperature values between 24°C and 29°C, indicating moderate temporal variation across the study area. Slight fluctuations were observed among the years; however, no significant long-term increasing or decreasing trend was evident during the study period. The spatial

and temporal variation of water temperature at different monitoring stations from 2018 to 2023 is presented in Figure 2.

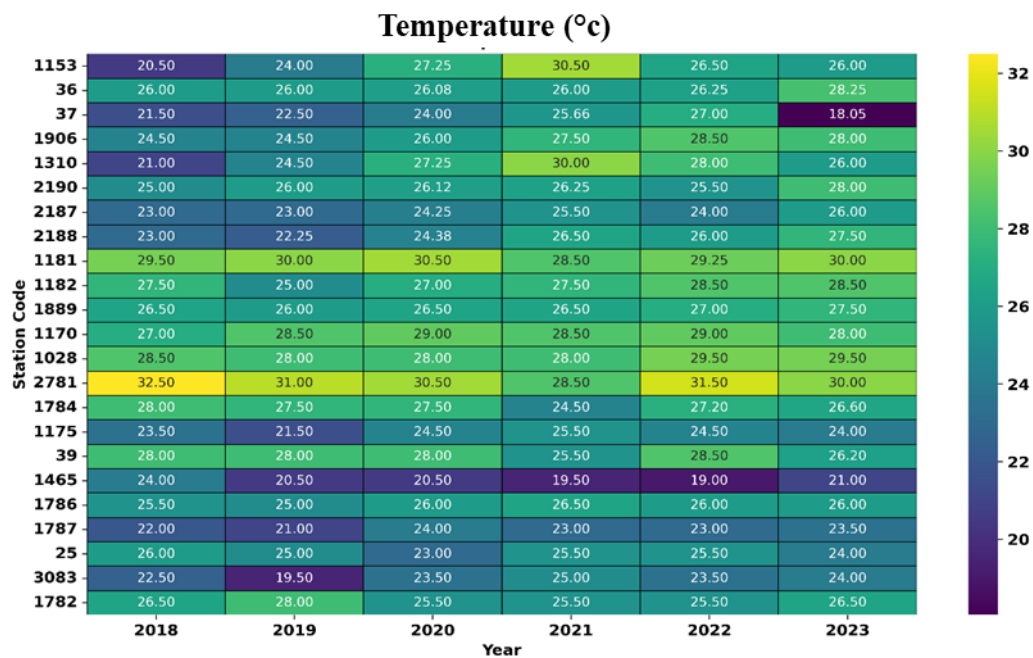


Figure 2 Spatial and temporal variation of temperature at different monitoring stations during 2018-2023

ii. pH:

The observed pH values ranged from approximately 7.15 to 8.50 during the study period, indicating slightly alkaline conditions across most monitoring locations. The highest pH values were observed at 1181 station (downstream of Narayanpura Dam, Karnataka) (approximately 8.50 in 2019) and 1170 (approximately 8.35 in 2023), which might be due to higher photosynthetic activity and the impact of agriculture runoff, which increases alkalinity. On the other hand, Station 1465 recorded the minimum pH value of 7.15 in 2019, whereas Stations 3083 and 1175 also exhibited lower pH levels during certain years of the study period. The lower pH values may be influenced by localized organic matter decomposition, inflow of slightly acidic runoff, and reduced buffering capacity. Overall, the pH values at all monitoring stations remained within the permissible limits prescribed by the Bureau of Indian Standards (BIS) and the designated best-use criteria defined by the Central Pollution Control Board (CPCB). The spatial and temporal variation of pH values at different monitoring stations from 2018 to 2023 is presented in Figure 3.

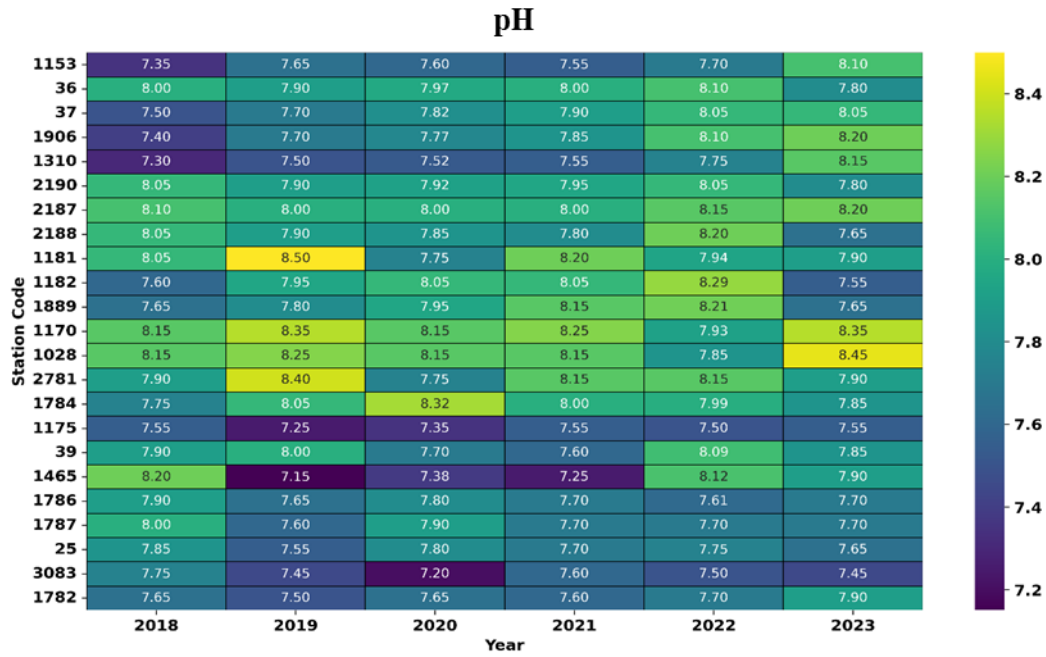


Figure 3 Spatial and temporal variation of pH at different monitoring stations during 2018-2023

**iii. Electrical conductivity:**

Figure 4 illustrates the spatial and temporal variation of electrical conductivity (EC) at different monitoring stations from 2018 to 2023. EC showed high spatial variability from 300 to 1500  $\mu\text{mho}/\text{cm}$  at the majority of stations, corresponding to a moderate ionic strength typical of river systems under agricultural and domestic wastewater influence. Nevertheless, very high conductivity values in the order of 30,000  $\mu\text{mho}/\text{cm}$  were recorded for station 1906 in the year 2018. For station 1782 in the range of 17,000 to 32,000  $\mu\text{mho}/\text{cm}$  for the duration of the study, which represent extreme ionic contamination and possibly from industrial aqueous discharges or salinity intrusion. In contrast, lower EC values were recorded at Stations 36 (range 220.5 and 1084  $\mu\text{mho}/\text{cm}$ ), 2187 (range from 393 to 517  $\mu\text{mho}/\text{cm}$ ), and 3083 (388.5-711  $\mu\text{mho}/\text{cm}$ ), reflecting comparatively better water quality conditions.

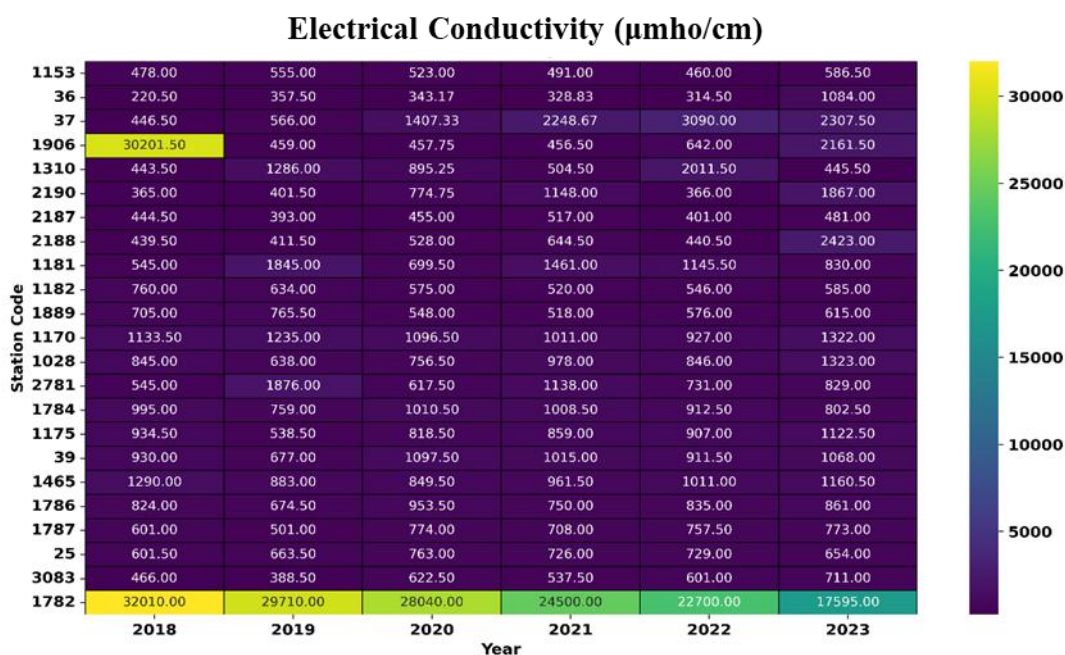


Figure 4 Spatial and temporal variation of pH at different monitoring stations during 2018-2023

iv. **Dissolved Oxygen:**

The dissolved oxygen (DO) levels were observed in a healthy range (around 4-8.35 mg/L) throughout the study period, indicating that the river has a strong self-purification ability. The maximum DO were found at stations 1181 and 2781 about 8 mg/L which associated with higher flow turbulence, aeration, and lower organic pollution loads. Conversely, Station 1782 recorded the minimum DO concentration of 4.45 mg/L in 2020, whereas Stations 2190 and 36 consistently exhibited lower values during several years of the study period. Reduced DO concentrations may indicate higher organic matter decomposition, limited reaeration, and increased biological activity. The negative correlation between DO and BOD/coliform at a number of stations also supports the associations of organic pollution with oxygen usage. Although there were several highly organically-polluted readings, the stable DO at most of the sites also exemplifies the effect of reaeration and dilution in maintaining the environmental balance. The spatial and temporal variation of water DO at different monitoring stations from 2018 to 2023 is presented in Figure 5.

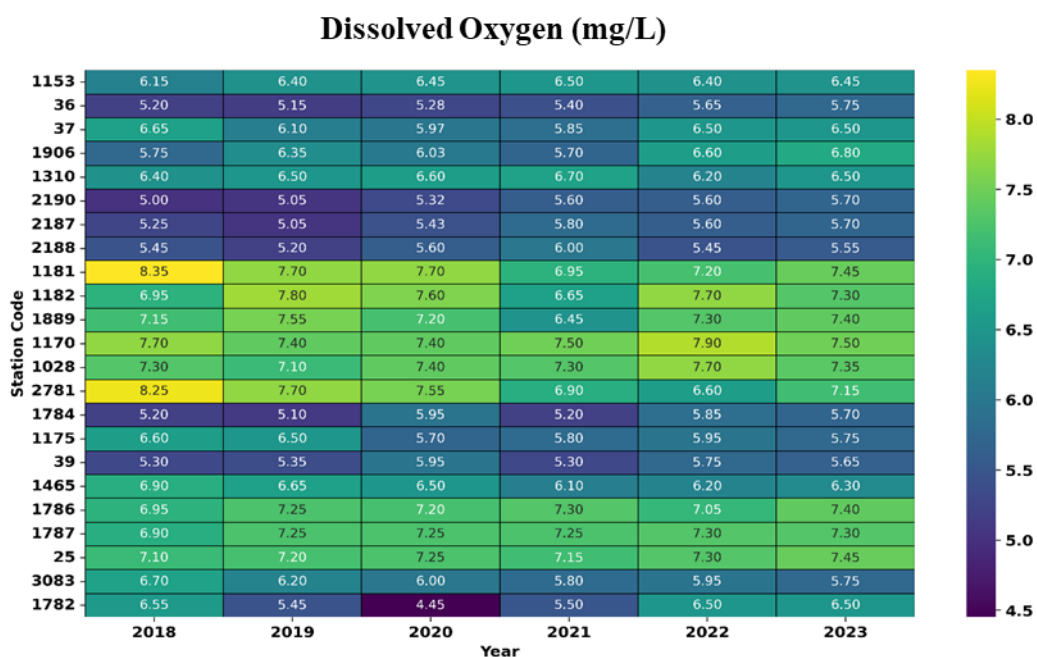


Figure 5 Spatial and temporal variation of dissolved oxygen at different monitoring stations during 2018-2023

**v. Biochemical Oxygen Demand:**

The observed BOD values ranged from 1.10 mg/L to 33.25 mg/L throughout the study period. The highest BOD value of 33.25 mg/L was recorded at Station 1170 in 2019, followed by Station 1784 with 25.00 mg/L in 2018 and Station 1465 with 16.50 mg/L in 2018. These elevated BOD levels indicate higher organic pollution and increased microbial decomposition activity at these locations. In contrast, lower BOD values were observed at Stations 1787, 3083, and 25, where the values generally ranged between 1.10 mg/L and 2.65 mg/L, indicating comparatively better water quality conditions and lower organic contamination. Most monitoring stations exhibited BOD values between 1.5 mg/L and 5.0 mg/L during the study period. Overall, the results reveal noticeable spatial and temporal variations in BOD concentrations across the monitoring network, reflecting differences in organic load and anthropogenic influences in the study area. Figure 6 illustrates the spatial and temporal variation of biochemical oxygen demand (BOD) at different monitoring stations during 2018-2023.

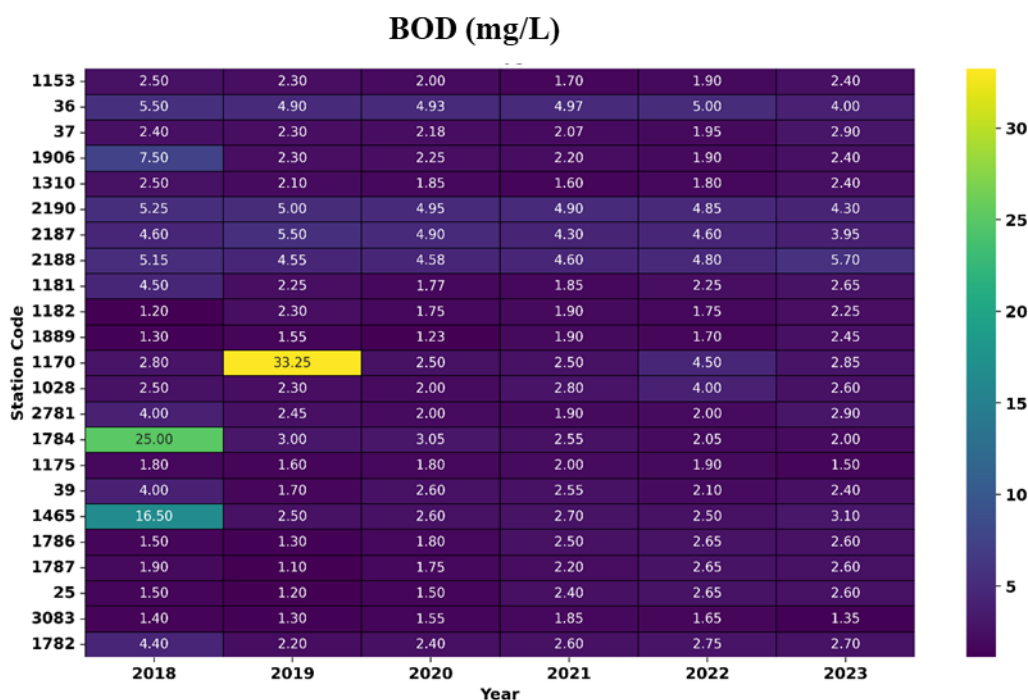


Figure 6 Spatial and temporal variation of biochemical oxygen demand at different monitoring stations during 2018-2023

**vi. Nitrate:**

Nitrate concentrations ranged from 0.05 mg/L to 25.22 mg/L during the study period. The highest nitrate concentration was recorded at Station 1465 (Wadapally, downstream of the Musi River confluence) in 2023 (25.22 mg/L), followed by Station 1889 in 2022 (23.84 mg/L) and Station 2781 in 2019 (23.40 mg/L), indicating significant nutrient enrichment likely due to agricultural runoff and domestic wastewater discharge. In contrast, lower nitrate concentrations were observed at Stations 1170, 1028, 25, and 1787, where values generally remained below 2 mg/L, reflecting comparatively better water quality conditions. Most monitoring stations showed moderate nitrate concentrations between 1 mg/L and 5 mg/L throughout the study period. Overall, the results indicate noticeable spatial and temporal variations in nitrate levels across the study area, influenced by land use practices and anthropogenic activities. Figure 7 presents the spatial and temporal variation of nitrate concentrations across the monitoring network during 2018-2023.

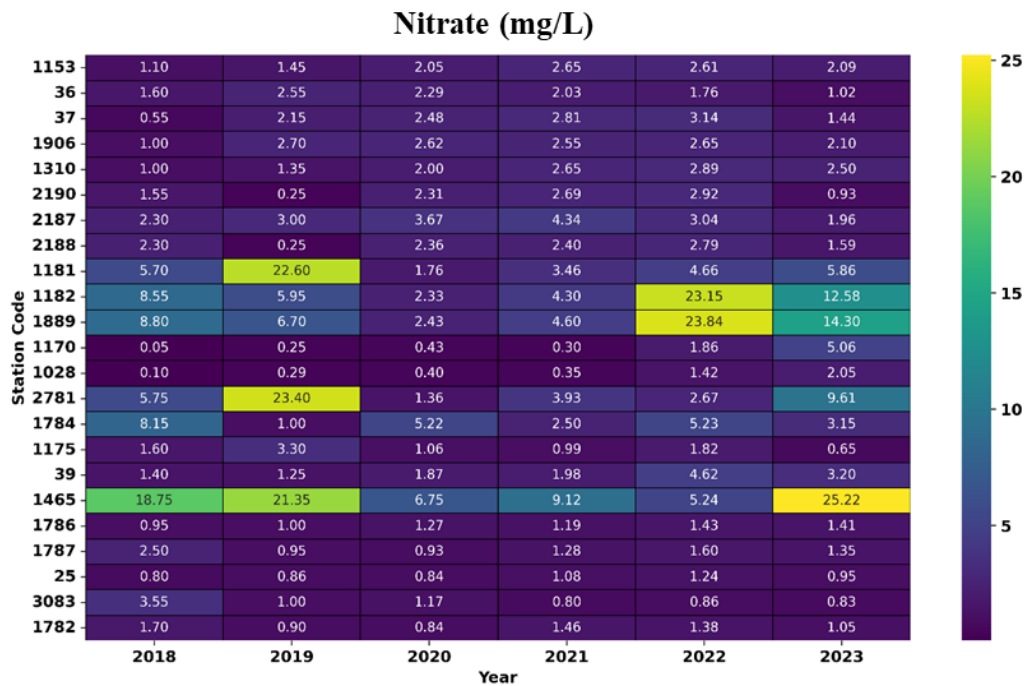
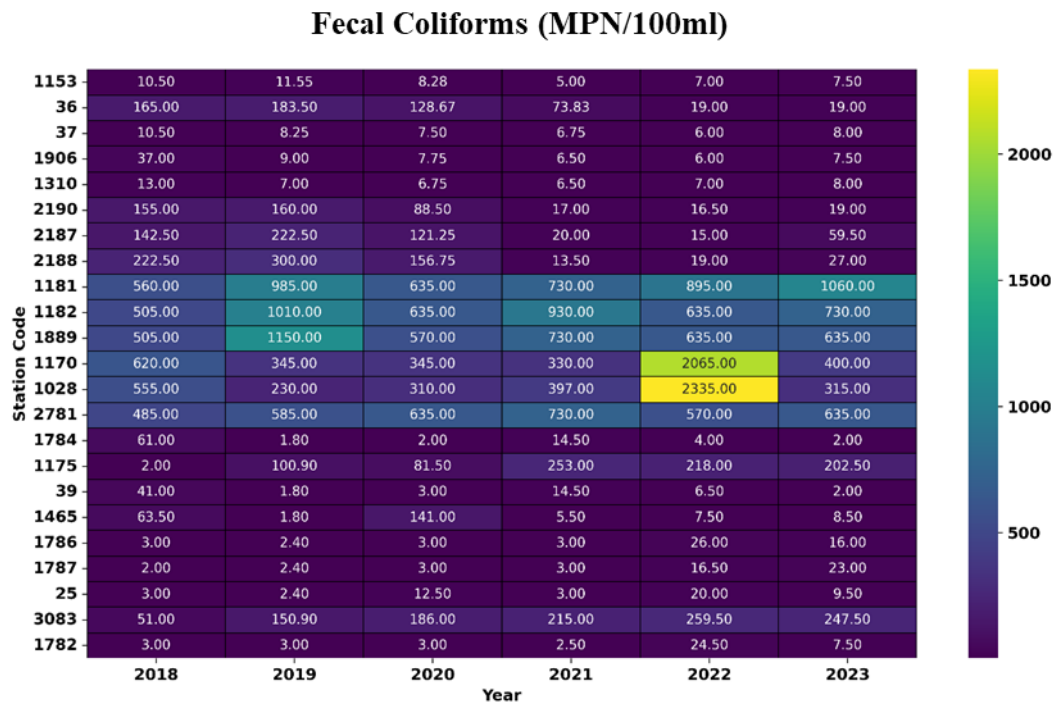


Figure 7 Spatial and temporal variation of nitrate at different monitoring stations during 2018-2023

**vii. Fecal Coliforms:**

Figure 8 illustrates the spatial and temporal variation of faecal coliform concentrations at different monitoring stations during 2018-2023. The observed faecal coliform concentrations showed considerable variation across the study period, ranging from 1.80 MPN/100 mL to 2335 MPN/100 mL. The highest concentration was recorded at Station 1028 in 2022 (2335 MPN/100 mL), followed by Station 1170 in 2022 (2065 MPN/100 mL) and Station 1889 in 2019 (1150 MPN/100 mL). These elevated values indicate significant microbial contamination, likely associated with untreated domestic sewage discharge and anthropogenic activities. Moderately high faecal coliform concentrations were observed at Stations 1181, 1182, 1889, and 2781, where values frequently exceeded 500 MPN/100 mL during the study period. In contrast, comparatively lower concentrations were recorded at Stations 1786, 1787, 25, and 1782, where values generally remained below 30 MPN/100 mL, indicating relatively better water quality conditions. Overall, the results reveal substantial spatial and temporal variability in faecal coliform levels across the monitoring network, reflecting differences in sewage inputs and sanitation conditions within the river basin.



*Figure 8 Spatial and temporal variation of fecal coliforms at different monitoring stations during 2018-2023*

**viii. Total Coliforms:**

Figure 9 illustrates the spatial and temporal variation of total coliform concentrations at different monitoring stations during 2018-2023. The observed total coliform concentrations ranged from 20 MPN/100 mL to 46250 MPN/100 mL throughout the study period, indicating substantial spatial and temporal variability across the monitoring network. The highest concentration was recorded at Station 1170 in 2022 (46250 MPN/100 mL), followed by Station 1028 in 2022 (17675 MPN/100 mL) and Station 1889 in 2019 (2400 MPN/100 mL). These elevated values indicate severe microbial contamination, likely resulting from untreated sewage discharge, urban runoff, and anthropogenic activities within the river basin. Moderately high total coliform concentrations were observed at Stations 1181, 1182, 1889, 2781, and 3083, where values frequently exceeded 1000 MPN/100 mL during the study period. In contrast, comparatively lower concentrations were recorded at Stations 37, 1784, 1465, and 1153, indicating relatively better water quality conditions. Overall, the results demonstrate considerable spatial and temporal fluctuations in total coliform levels across the study area, reflecting variations in sanitation conditions, wastewater discharge, and human activities along the river system.

### Total Coliforms (MPN/100ml)

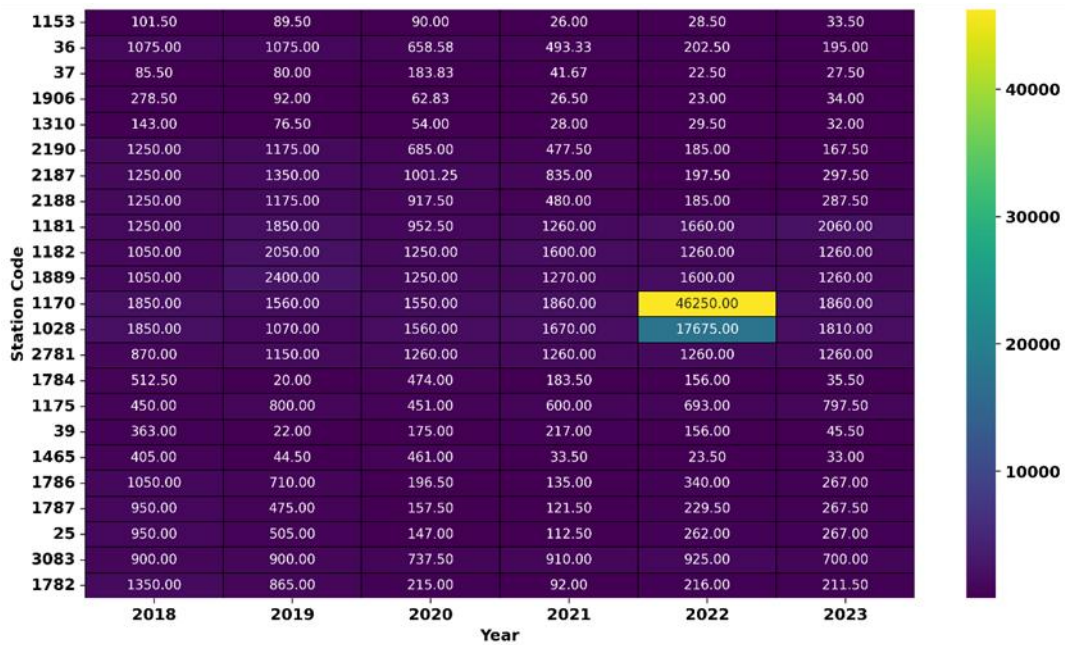


Figure 9 Spatial and temporal variation of total coliforms at different monitoring stations during 2018-2023

### 3.4.2 Water Quality in Tributaries of Krishna River

#### I. Temperature:

The temperature values across the Krishna River tributaries showed considerable spatial and temporal variation during 2018-2023. The Bhima River exhibited the widest fluctuation in temperature, ranging from about 24.5°C at station code 28 (Bhima At Takli, Solapur) during 2018-2019 to 35.0°C at station code 1188 in 2020, indicating significant thermal variation in downstream stretches. In the Tungabhadra River, temperature varied between 18.0°C and 31.5°C, with the highest value observed at station code 2776 (D/S of Gangawathi) in 2022, likely influenced by seasonal climatic conditions and reduced river discharge. The Panchaganga River recorded a maximum temperature of 33.0°C at station code 1311 in 2020 and a minimum of 23.5°C at station code 1904 in 2019, reflecting the impact of urban and industrial activities around Kolhapur.

The Malaprabha River maintained comparatively lower temperatures, with the highest value of 29.0°C recorded at station code 1164 during 2019-2020, while the lowest temperature of 18.5°C was observed at station code 1186 (D/S of Aihole Town) in 2020, associating with lower anthropogenic stress and better flow conditions. Similarly, the Bhadra River showed

relatively stable thermal conditions, with the highest temperature of 29.0°C at station code 1387 in 2020 and the lowest value of 19.0°C at station code 2771 in 2019, likely due to dense vegetation cover, reservoir influence, and comparatively lesser pollution load.

In contrast, the Musi River consistently exhibited elevated temperatures, ranging from 27.4°C at station code 3082 (Kasaniguda Reservoir) in 2022 to 29.7°C at station code 4659 (Peerajadiguda) in 2019, reflecting strong urban and anthropogenic influences. Overall, the Bhima and Musi rivers experienced comparatively higher thermal stress, whereas the Malaprabha and Bhadra rivers maintained relatively stable thermal conditions. The Table 9s provides monitoring station-wise average annual Temperature in the Krishna river tributaries during 2018-2023.

## **II. pH:**

The pH of the Krishna River tributaries during 2018-2023 indicate predominantly neutral to slightly alkaline conditions, suggesting generally stable hydrochemical behavior across the basin. In the Bhima River, pH values range from 7.35 to 8.50, with the highest value recorded at station code 1184 (Ferozabad Village, D/S) and the lowest at station code 1190 (Bundgarden, Pune), reflecting minor alkalinity influenced by urban sewage. The Tungabhadra River exhibits a relatively narrow pH range of 7.10 to 8.40, where the maximum occurs at station code 2776 (D/S of Gangawathi) and the minimum at station code 1785 (Manthralayam), indicating stable buffering capacity. In the Panchaganga River, pH varies between 7.10 and 8.10, with the highest at station code 2163 (Shirol) and lowest at station code 1905 (D/S of Kolhapur), suggesting slight anthropogenic influence near urban stretches. The Malaprabha River shows values ranging from 7.40 to 8.40, with maximum pH at station code 1186 (Aihole Town) and minimum at station code 1187 (Khanapur), indicating moderate alkalinity likely due to geological contributions. The Bhadra River maintains a comparatively narrower and slightly lower range of 6.80 to 7.80, with the highest at station code 1387 (Bhadravathi) and lowest at station code 2771, reflecting near-neutral conditions with minimal disturbance. In contrast, the Musi River exhibits pH values between 7.08 and 8.40, with the highest observed at station code 3082 (Kasaniguda Reservoir) and the lowest at station code 4254 (Rudravelly Bridge), indicating fluctuating conditions influenced by urban discharge yet remaining within permissible limits. Overall, the pH across all tributaries remains within the acceptable range (6.5-8.5), suggesting that despite localized anthropogenic pressures, the river system retains its natural buffering capacity without significant acidification or extreme alkalinity. The Table

10S Provides monitoring station-wise average annual pH in the Krishna river tributaries during 2018-2023.

### III. **Electrical conductivity:**

The analysis of Electrical Conductivity (EC) across the Krishna River tributaries indicates substantial spatial and temporal variability, reflecting differences in anthropogenic influence, geological characteristics, and flow conditions. In the Bhima River, EC values exhibit the highest variability among all tributaries, with a maximum recorded at station code 1188 (Narsingpur) reaching 5277  $\mu\text{mho/cm}$  (2022) and a minimum at station code 1190 (Pune D/S Bundgarden) of approximately 470  $\mu\text{mho/cm}$  (2019), indicative of strong pollution inputs and salinity build-up in downstream stretches. The Tungabhadra River shows moderate variability, with the highest EC at station code 1174 (Kurnool U/S) reaching 1529  $\mu\text{mho/cm}$  (2023) and the lowest at station code 38 (Honnali Bridge) around 196  $\mu\text{mho/cm}$  (2018), suggesting localized anthropogenic impacts downstream.

In the Panchaganga River, EC ranges from a minimum value of 138.5  $\mu\text{mho/cm}$  at station code 1904 (2023) to a maximum of 1874.5  $\mu\text{mho/cm}$  (2022) at the same station, indicating episodic pollution or discharge events. The Malaprabha River exhibits relatively high EC levels, with a maximum at station code 2764 (Badami Bridge) of 1288  $\mu\text{mho/cm}$  (2023) and a minimum at station code 1187 (Khanapur) of around 194  $\mu\text{mho/cm}$  (2019). In contrast, the Bhadra River maintains comparatively low EC values, with a maximum value of about 250  $\mu\text{mho/cm}$  at station code 1387 (2018 and 2020) and a minimum value of around 83  $\mu\text{S/cm}$  at station code 2771 (for both 2020 and 2021), indicating relatively better water quality.

The Musi River shows consistently high EC levels, reflecting severe urban and industrial influence, with the highest value at station code 3082 (Musi Reservoir) reaching 1844  $\mu\text{mho/cm}$  (2019) and the lowest at station code 4253 (Bapughat) around 1178  $\mu\text{mho/cm}$  (2023). Overall, the EC trends highlight that the Bhima and Musi rivers are significantly impacted by anthropogenic activities, while Bhadra remains relatively unpolluted, and other tributaries exhibit moderate variability.

### IV. **Dissolved Oxygen:**

The Bhima River shows pronounced fluctuations, with the lowest DO value of 3.5 mg/L recorded at station codes 1189 and 1190 in near Pune, indicating substantial organic pollution

load, while the highest value of 16.3 mg/L at station code 2656 (Ujani backwater) represents an anomalous condition. Excluding this outlier, the Bhima River generally ranges between 3.5 and 9.1 mg/L, reflecting gradual downstream recovery. The Tungabhadra River maintains relatively stable DO levels, ranging from 4.1 mg/L (station code 29) to 7.7 mg/L (station code 1029), and indicative of moderate ecological conditions. Similarly, the Panchaganga River exhibits a narrow DO range of 5.0-6.7 mg/L (station codes of 1904 and 1311), suggesting balanced oxygen dynamics.

The Malaprabha River shows comparatively higher variability, with DO ranging from 5.0 mg/L to 9.0 mg/L (station code 1164), indicating generally good oxygen availability with episodic enhancement. The Bhadra River demonstrates consistently healthy conditions, with DO values between 5.6 mg/L (station code 1387) and 7.4 mg/L (station code 2765). In contrast, the Musi River exhibits critically depleted DO levels, with a minimum of 0.1 mg/L observed at station codes 4253 and 2339, reflecting near-anoxic conditions in stretches impacted by untreated urban discharge from Hyderabad, while downstream improvement is evident with a maximum DO of 6.8 mg/L at station code 3082. Overall, the DO regime highlights severe oxygen stress in highly urbanised tributaries, moderate conditions in regulated river stretches, and relatively healthy oxygen levels in less impacted sub-basins, emphasising the role of wastewater inputs and dilution mechanisms in controlling riverine oxygen dynamics. The Table 12S provide the monitoring station-wise average annual DO in the Krishna River tributaries during 2018-2023.

#### **V. Biochemical Oxygen Demand:**

The Bhima River exhibits the widest fluctuation, with the highest BOD observed at station code 1189 (Pune U/S Vithalwadi) reaching 22.5 mg/L (2023), while the lowest occurs at station code 1167 (Yadgir) with values around 2.5 mg/L, resulting in a broad range from 2.5 to 22.5 mg/L, indicating severe organic pollution in upstream urban stretches and gradual improvement downstream. In the Tungabhadra River, BOD remains relatively moderate, with a peak of 11.0 mg/L at station code 2776 (D/S of Gangawathi, 2022) and a minimum value of about 1.8 mg/L at station code 1785 (Manthralayam), suggesting localized pollution events. The Panchaganga River shows episodic high BOD levels, particularly at station code 1905 (D/S of Kolhapur Town) with 11.0 mg/L (2018), while the lowest value of 1.6 mg/L occurs at station code 1904, indicative of urban discharge influence.

The Malaprabha River maintains relatively low BOD levels, with a maximum value of 3.0 mg/L at station code 1164 (2018) and a minimum value of 1.5 mg/L at station code 2764, resulting in a narrow range, reflecting comparatively better water quality. Similarly, the Bhadra River shows low organic pollution, with BOD ranging from about 1.3 mg/L at station code 2771 to around 4.9 mg/L at station code 1387. In stark contrast, the Musi River demonstrates critically high BOD levels, with the maximum recorded at station code 4656 (Moosarambagh Bridge, Hyderabad) reaching 40 mg/L (2019) and the minimum at station code 4254 (Rudravelly Bridge) around 3.2 mg/L, resulting in a very high range, clearly reflecting intense urban and industrial pollution. Overall, the analysis indicates that while tributaries like Bhadra and Malaprabha maintain relatively good water quality, the Bhima and especially the Musi rivers are heavily impacted by organic pollution, necessitating targeted management interventions. The Table 13S provides monitoring station-wise average annual BOD in the Krishna river tributaries during 2018-2023.

#### VI. Nitrate:

The Bhima River exhibits pronounced fluctuations, with the highest nitrate concentration recorded at station code 1184 (Ferozabad Village) reaching 33.8 mg/L (2023), while the lowest values are recording 0.3 mg/L at stations such as 1183 and 1167 during certain years, indicating strong spatial heterogeneity and episodic pollution events, particularly in downstream stretches. In the Tungabhadra River, nitrate concentrations remain generally low, with most values below 1 mg/L; however, localized spikes are evident, with a maximum of 10.5 mg/L at station code 2776 (D/S of Gangawathi, 2022) and a minimum of value of about 0.2 mg/L at station code 29, suggesting occasional nutrient influx likely associated with seasonal runoff or point-source inputs.

The Panchaganga River showed ranging from 1.1 mg/L at station code 1905 to around 4.4 mg/L at station code 2163 (2022), indicating moderate nutrient enrichment with limited variability. In contrast, the Malaprabha River demonstrates a clear increasing trend, with nitrate concentrations rising significantly from around 1.3 mg/L to as high as 21.4 mg/L at station code 2764 (2023), and similarly high values (approximately 20.9 mg/L) at station code 1186, reflecting intensified agricultural activities and fertilizer leaching. The Bhadra River maintains comparatively low nitrate concentrations, varying between around 0.1 mg/L at station code 2771 and a maximum of value approximately 5.6 mg/L (2022), indicating relatively good water quality and minimal anthropogenic influence.

In stark contrast, the Musi River exhibits consistently elevated nitrate levels, with the maximum observed at station code 4254 (Rudravelly Bridge) reaching 30.1 mg/L (2023), while the minimum values remain relatively high (around 4.0 mg/L), reflecting persistent nutrient pollution driven by urban sewage discharge and industrial effluents in the Hyderabad region. Overall, the analysis indicates that while rivers such as Bhadra and Tungabhadra maintain relatively low nitrate concentrations, the Bhima River shows high variability, and the Malaprabha and especially the Musi River are significantly impacted by nutrient pollution, posing serious risks of eutrophication and requiring focused management interventions. The Table 13S provide monitoring station-wise average annual nitrate in the Krishna river tributaries during 2018-2023.

## VII. **Fecal coliforms:**

The spatio-temporal analysis of fecal coliform concentrations across the major tributaries of the Krishna River basin reveals substantial variability, indicating differing levels of microbial contamination. The Bhima River exhibits the highest fluctuation, with an extreme peak at station code 1183 (Gangapur Village) reaching 130115 MPN/100 mL (2023), while the lowest values recoding 13 MPN/100 mL) occur at station code 1192, reflecting severe sewage contamination in certain stretches. In the Tungabhadra River, the maximum value of 25450 MPN/100 mL is observed at station code 2770 (Harihar Water Supply Intake, 2018), and the minimum value of 51 MPN/100 mL) at downstream stations such as 1174 and 1785, indicating localized pollution hotspots. The Panchaganga River shows relatively low contamination, with a maximum of 58 MPN/100 mL at station code 1904 and a minimum of about 5 MPN/100 mL at station code 1311.

The Malaprabha River displays significant variation, with a peak of 25250 MPN/100 mL at station code 1187 and a minimum value of 520 MPN/100 mL at station code 1164. Similarly, the Bhadra River ranges from a maximum of 27500 MPN/100 mL at station code 1387 to a minimum of 23 MPN/100 mL at station code 2771. In contrast, the Musi River shows comparatively moderate but persistent contamination, with a maximum of 510 MPN/100 mL at station code 4660 and a minimum of 2.3 MPN/100 mL at station code 4254. Overall, the Bhima and Tungabhadra rivers exhibit extreme contamination levels, while Panchaganga maintains relatively better microbial quality, and the Musi River reflects continuous urban pollution. The Table 15S provides monitoring station-wise average annual fecal coliform level in the Krishna river tributaries during 2018-2023.

### VIII. Total coliforms:

The Bhima River shows extreme fluctuations, with the highest value recorded at station code 1184 (Ferozabad Village) reaching 175550 MPN/100 mL (2023), while the lowest (around 225 MPN/100 mL) is observed at station code 1192, indicating severe contamination in several stretches. In the Tungabhadra River, the maximum value of 46100 MPN/100 mL occurs at station code 2770 (Harihar Water Supply Intake, 2018), while the minimum (292 MPN/100 mL) is also observed at the same station in later years, suggesting strong temporal variability and localized pollution.

The Panchaganga River exhibits relatively low total coliform levels, with a maximum of 495 MPN/100 mL at station code 1905 and a minimum value of 23 MPN/100 mL at the same station, indicating comparatively better microbial quality. The Malaprabha River shows considerable variation, with a peak of 45450 MPN/100 mL at station code 1187 and a minimum value of 932.5 MPN/100 mL at station code 1186. Similarly, the Bhadra River records very high contamination, with a maximum of 49500 MPN/100 mL at station code 1387 and a minimum value of 180 MPN/100 mL at station code 2771.

In contrast, the Musi River shows moderate but persistent contamination, with the highest value of 1600 MPN/100 mL at station code 4660 (2019) and the lowest (around 52 MPN/100 mL) at station code 3082. Overall, the Bhima, Tungabhadra, Malaprabha, and Bhadra rivers exhibit severe microbial contamination at several locations, whereas Panchaganga maintains relatively better conditions, and the Musi River reflects continuous urban pollution influence. The Table 16S provides monitoring station-wise average annual total coliforms levels in the Krishna River tributaries during 2018-2023.

### 3.5 Water Quality Index

Calculation of water quality index (WQI) was carried out by following the ‘weighted arithmetic index method’ (Brown et al. 1970), using the equation

$$WQI = \frac{\sum Q_n W_n}{\sum W_n}$$

where  $Q_n$  is the quality rating of nth water quality parameter,

$W_n$  is the unit weight of nth water quality parameter.

The quality rating  $Q_n$  is calculated using the equation:

$$Q_n = 100[(V_n - V_l)/V_s - V_l]$$

Where,  $V_n$  is the actual amount of nth parameter present,  $V_i$  is the ideal value of the parameter [ $V_i = 0$ , except for pH ( $V_i = 7$ ) and DO ( $V_i = 14.6$  mg/l)],  $V_s$  is the standard permissible value for the nth water quality parameter.

Unit weight ( $W_n$ ) is calculated using the formula

$$W_n = K/V_s$$

where k is the constant of proportionality and it is calculated using the equation

$$K = [1/\sum 1/V_s = 1,2,3 \dots n]$$

The water quality status (WQS) according to WQI is shown in Table 10.

Table 10: WQI range, status and possible usage of the water sample (Brown et al. 1972)

WQI	Water quality status (WQS)	Possible usage
0-25	Excellent	Drinking, irrigation and industrial
26-50	Good	Drinking, irrigation and industrial
51-75	Poor	Irrigation and industrial
76-100	Very	poor Irrigation
Above	100	Unsuitable for drinking and fish culture Proper treatment required before use

The assessment of water-quality index (WQI) in the Krishna River basin using arithmetic WQI during 2018-2023 shows high spatial and temporal fluctuations (Bora et al. 2017). The Figure 10 represents Spatial distribution of Water Quality Index (WQI) in the Krishna River Basin during 2018-2023: (a) 2018, (b) 2019, (c) 2020, (d) 2021, (e) 2022, and (f) 2023. In addition to the Table 17S provides water quality index for different monitoring station in the Krishna River and its major tributaries during 2018-2023.

The Krishna River in Maharashtra at 1153 (Rajapur Weir), 37 (Miraj) and 1310 (Kurundwad) is predominantly in the good category, with WQI ranging mostly around 60 to 80 across the period. Nevertheless, 1906 (downstream of Islampur) was recorded as having a bad WQI (around 203) in 2018 and then improved in the following years. In addition, the stations such as 36 (Karad), 2187 (Kshetra Mahuli), 2188 (Krishna-Venna Sangam), and 2190 (Wai) were found to be poor (WQI > 100). Even headwater regions are known to receive human contributions from domestic discharge and agricultural runoff.

In Karnataka, WQI portrays a mixed scenario due to the cumulative impact of flow regulation, catchment activities and point sources of pollution. Stations such as 1028 (Tintini Bridge) and

2781 (downstream of Alamatti Dam) fall under good and poor categories, indicating variable water quality conditions over time. Other stations, including 1181 (downstream of Narayanpura Dam), 1182 (upstream of Ugarkhurd Barrage), 1889 (Ankali Bridge), and 1170 (downstream of Devasagar Bridge), generally maintain WQI values within the good range, although occasional spikes (e.g., 1170 in 2022: around 134) suggest episodic pollution events. These variations highlight the influence of regulated flows and intermittent pollutant inputs in the midstream section.

Further, in Telangana and Andhra Pradesh, the cumulative impact of Maharashtra and Karnataka becomes more evident. Stations such as 1784 (Thangadi), 39 (Gadwal Bridge), and 1465 (Wadapally, after Musi confluence) show moderate to poor water quality, with WQI values typically ranging from 70 to 90 and occasionally exceeding 100. The most degraded water quality condition along the main river was observed at Station 1782 (Hamsaladeevi), where WQI values consistently remained within the poor category throughout the study period, decreasing from approximately 157 in 2018 to around 108 in 2023. These high WQI values indicate the cumulative impact of upstream pollution sources and tributary inflows on downstream water quality conditions.

Among the tributaries, the Bhima River and Musi River are the major contributors to water quality deterioration. In the Bhima River, stations 1189 (Pune U/S Vithalwadi) and 1190 (Bundgarden, Pune) record extremely high WQI values, reaching unsuitable levels (around 408 in 2023 and about 311 in 2023, respectively). Other stations such as 1191, 1192, and 1188 also consistently fall within poor to very poor categories, indicating sustained pollution loads along the river course. The Musi River represents the most critical hotspot, with stations 4659 (Peerajadi Guda outlet), 2339 (Nagole), 4660 (peerajadiguda), and 4656 (Moosarambagh) showing extremely high WQI values, often exceeding 300 and reaching up to 724 (2020). This reflects severe contamination due to untreated urban wastewater from Hyderabad. The impact of this tributary is clearly visible at station 1465, where water quality declines following the confluence with the Krishna River.

In addition to these highly polluted tributaries, other tributaries exhibit relatively moderate to good WQI with localized disturbances. The Tungabhadra River (stations 1029, 2767, 2766, 1174, 1785) generally falls within the good category, although stations 2768 (D/S of HPF) and 2770 (Harihar) show poor conditions (WQI >100), indicating localized industrial or urban impacts. The Panchaganga River demonstrated a significant improvement trend, with Stations

1904 and 1905 shifting from very poor conditions in 2018, where WQI values exceeded 200, to good water quality conditions with WQI values ranging between 60 and 75 in the later years. The Malaprabha River (Stations 1187, 1164, 1186, and 2764) and the Bhadra River (Stations 1387, 1169, 2765, and 2771) predominantly maintained WQI values within the good category throughout the study period, indicating relatively stable water quality conditions and lower pollution pressure compared to the Bhima and Musi River.

Temporal analysis indicates that WQI trends across the basin are non-linear and characterized by fluctuations rather than consistent improvement or decline. Station 36 (Karad) showed temporary improvement in 2021 with a WQI value of 53, followed by deterioration in subsequent years, whereas Stations 1904 and 1905 in the Panchaganga River exhibited sustained improvement after 2018. In contrast, Station 1189 in the Bhima River showed increasing deterioration, particularly during 2023. These variations suggest that water quality conditions are strongly influenced by episodic pollution events, seasonal hydrological changes, and inconsistent wastewater management practices.

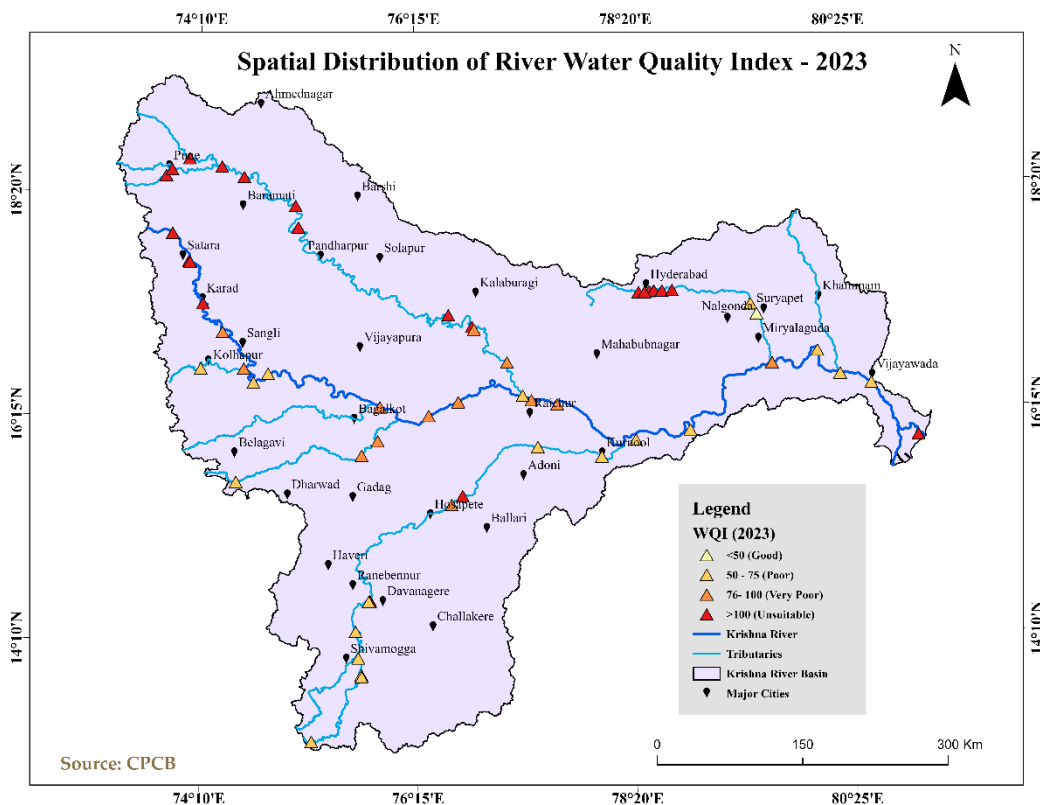


Figure 10 Spatial distribution River Water Quality Index during 2023

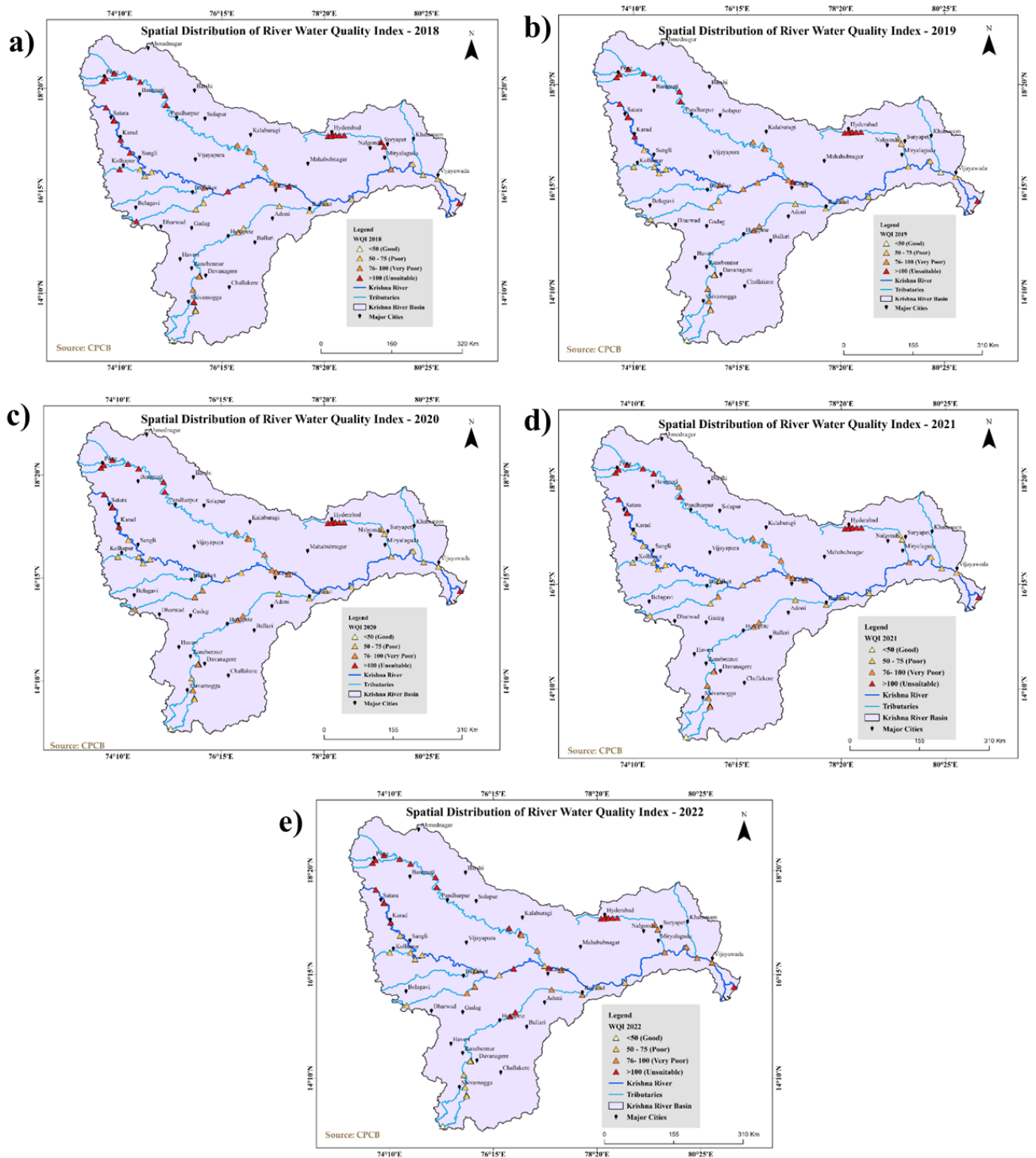


Figure 11 Spatial distribution of Water Quality Index (WQI) in the Krishna River Basin during 2018-2023: (a) 2018, (b) 2019, (c) 2020, (d) 2021, and (e) 2022

Overall, the results demonstrate that water quality degradation in the Krishna River basin is spatially heterogeneous and primarily governed by localized anthropogenic activities and tributary inflows. While the Musi and Bhima rivers are the most critical contributors to pollution, other tributaries such as Tungabhadra, Panchaganga, Malaprabha, and Bhadra also

influence regional water quality dynamics. The persistent deterioration observed at station 1782 (Hamsaladeevi) highlights the cumulative impact of these tributary inputs. Therefore, effective river basin management should prioritize pollution control at critical tributary sources and urban discharge points, alongside maintaining the relatively better conditions observed in less impacted sub-basins.

## **4. Groundwater Quality of Krishna River Basin**

### **4.1 Monitoring Details and Frequency**

The groundwater quality assessment for the Krishna River Basin was carried out using secondary data obtained from the Central Ground Water Board (CGWB) for the period 2019-2023. The monitoring network consists of observation wells and groundwater sampling locations distributed across different hydrogeological and administrative regions of the basin covering the states of Maharashtra, Karnataka, Telangana, and Andhra Pradesh. The monitoring locations include both shallow and deep groundwater sources representing major aquifer systems within the basin. The spatial distribution of monitoring stations was selected to capture variations in groundwater quality associated with geology, land use, urbanization, agricultural activities, and industrial influence.

Groundwater quality data were collected for major physico-chemical parameters including pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium ( $\text{Ca}^{2+}$ ), magnesium ( $\text{Mg}^{2+}$ ), sodium ( $\text{Na}^+$ ), potassium ( $\text{K}^+$ ), bicarbonate ( $\text{HCO}_3^-$ ), chloride ( $\text{Cl}^-$ ), sulfate ( $\text{SO}_4^{2-}$ ), nitrate ( $\text{NO}_3^-$ ), and fluoride ( $\text{F}^-$ ). The collected data were analyzed to understand the spatial and temporal variation of groundwater quality across the basin and to identify regions affected by salinity, hardness, nitrate contamination, fluoride enrichment, and other hydrochemical issues.

The monitoring frequency and number of sampling locations varied slightly between years depending on data availability and operational monitoring programs of CGWB. A total of 856 groundwater sampling points were considered for 2019, 89 for 2020, 112 for 2021, 1243 for 2022, and 1284 for 2023. The comparatively lower number of monitoring stations during 2020 and 2021 may be associated with limitations in field monitoring and data collection during that period, whereas a substantial increase in sampling coverage was observed during 2022 and 2023. The large spatial coverage of monitoring stations provides a comprehensive representation of groundwater quality conditions within the Krishna River Basin.

The groundwater quality data generated through this monitoring network were further utilized for spatial analysis, preparation of thematic maps using GIS techniques, and calculation of Groundwater Quality Index (GWQI) to evaluate the suitability of groundwater for drinking and other purposes. The monitoring framework therefore provides an important basis for understanding regional hydrochemical characteristics and supporting sustainable groundwater management within the basin.

## **4.2 Key Physico-Chemical Parameters**

Physico-chemical parameters play an important role in understanding the hydrochemical characteristics and suitability of groundwater for various purposes, particularly drinking and irrigation. These parameters provide information regarding the dissolved mineral content, ionic composition, salinity, alkalinity, and possible contamination sources influencing groundwater quality. Variations in physico-chemical characteristics are generally controlled by natural processes such as rock water interaction, weathering, dissolution of minerals, evaporation, and recharge conditions, along with anthropogenic activities including agricultural runoff, industrial discharge, domestic wastewater disposal, and excessive groundwater extraction. In the present study, major physico-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium ( $\text{Ca}^{2+}$ ), magnesium ( $\text{Mg}^{2+}$ ), sodium ( $\text{Na}^+$ ), potassium ( $\text{K}^+$ ), bicarbonate ( $\text{HCO}_3^-$ ), chloride ( $\text{Cl}^-$ ), sulfate ( $\text{SO}_4^{2-}$ ), nitrate ( $\text{NO}_3^-$ ), and fluoride ( $\text{F}^-$ ) were analyzed to evaluate the spatial distribution and groundwater quality status across the Krishna River Basin during the study period.

*Table 10 Statistics of groundwater quality parameters from 2019 to 2023*

Year		pH	EC	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	NO <sub>3</sub> <sup>-</sup>	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	F <sup>-</sup>	TDS
2023	Max	9.46	84660	3234	41665	1697	1989	7050	1513	796	22437	1229	6.44	-
	Min	5.13	70	12	3	1	1	20	2	1	3	1	0.01	-
	Avg	7.44	1722	441	242	101	58	440	96	48	177	28.33	0.89	-
2022	Max	10.45	16500	1443	5530	2361	1534	3200	621	631	2119	1270	168	-
	Min	3.8	38	12	0.9	0.1	0.1	20	4	1	2.8	0.1	0.01	-
	Avg	7.66	1476	351	210	97	53	362	70	45	148	27	0.94	-
2021	Max	8.21	3200	781	510	509	311	1340	224	199	335	103	3.54	1708
	Min	6.6	106	24	7	1	3	35	6	5	2	1	0.1	69
	Avg	7.44	1183	341	114	64	52	364	82	38	77	8.16	0.73	709
2020	Max	9.3	5860	712	1392	329	408	1340	224	189	612	262	1.04	1337
	Min	7.3	205	66	11	5	3	55	8	5	12	1	0.06	131
	Avg	7.99	1169	291	137	74	54	347	58	51	91	14	0.38	612
2019	Max	9.93	9980	1582	2084	2980	593	1890	506	331	2036	561	10	5988
	Min	5.7	48	6	7	1	1	9	2	1	1	1	0.01	31
	Avg	7.9	1539	308	216	126	51	389	80	47	148	26	0.94	927

(No of sampling points in 2023:1284, 2022:1243, 2021:112, 2020:89, 2019: 856)

#### 4.2.1 pH

pH is an important physico-chemical parameter that indicates the acidity or alkalinity of groundwater. It plays a significant role in controlling chemical reactions, solubility of minerals, and mobility of dissolved constituents in groundwater systems. The pH of water also affects taste, corrosivity, and suitability for drinking and domestic use. According to BIS (IS 10500:2012), the desirable pH range for drinking water is 6.5 to 8.5.

Based on the groundwater quality data for the year 2023 obtained from the Central Ground Water Board, the pH values in the Krishna River Basin vary from 5.13 to 9.46, with an average value of 7.44. The majority of groundwater samples fall within the neutral to slightly alkaline range, indicating that groundwater chemistry in most parts of the basin is influenced by natural buffering processes associated with mineral weathering. The slightly alkaline nature of groundwater observed at many monitoring locations may be attributed to dissolution of carbonate and silicate minerals present in granitic, gneissic, and basaltic formations. Rock-water interaction and bicarbonate alkalinity contribute to stabilization of pH within acceptable limits. However, isolated locations showing lower pH values may be influenced by localized recharge conditions, soil characteristics, or anthropogenic inputs, whereas higher pH values may be related to evaporation effects or prolonged residence time of groundwater.

Comparison with previous years (2019-2022) indicates that the average pH values across the basin remain relatively stable, generally ranging between 7.44 and 7.99, suggesting consistent

hydrochemical conditions over time. The spatial distribution map of pH for 2023 shows that most monitoring stations fall within permissible limits, with only a few localized pockets exceeding the desirable range, which may affect corrosivity or scaling behaviour of groundwater. Overall, groundwater in the Krishna River Basin is largely suitable with respect to pH, as the majority of samples comply with drinking water standards. Continuous monitoring is nevertheless important to identify localized deviations and to understand long-term hydrochemical changes within the basin.

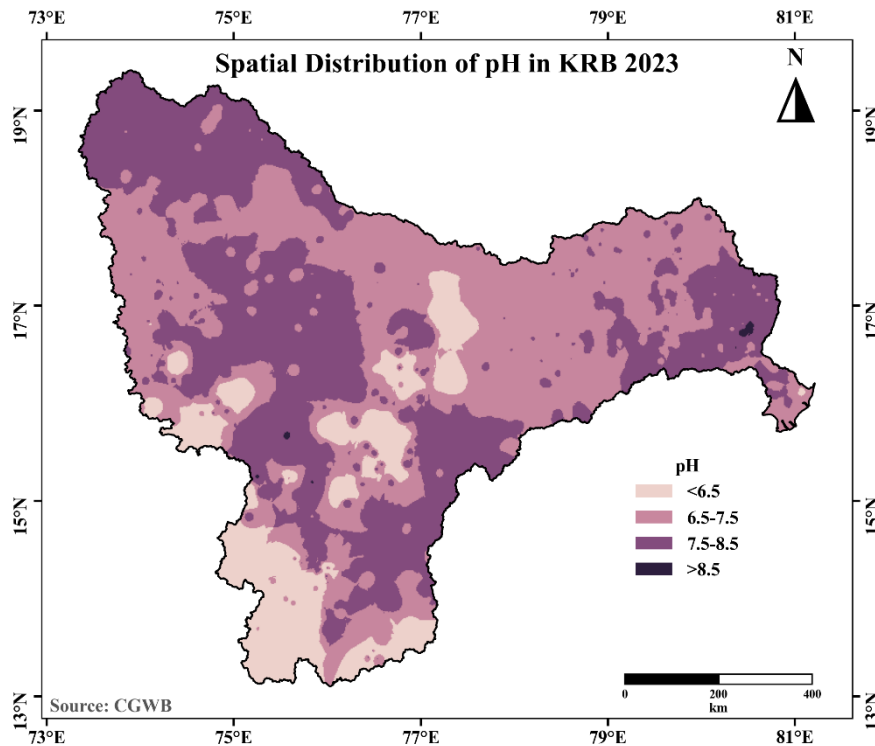


Figure 12 Spatial distribution of pH in Krishna River Basin (2023)

#### 4.2.2 Electrical Conductivity (EC)

Electrical Conductivity (EC) is an important physico-chemical parameter that indicates the ability of water to conduct electrical current, which is directly related to the concentration of dissolved ions present in groundwater. It is commonly used as a measure of salinity and overall mineralization of water. Higher EC values generally indicate increased levels of dissolved salts, which may affect the suitability of groundwater for drinking and irrigation purposes.

Based on the groundwater quality data for the year 2023 obtained from the Central Ground Water Board, the EC values in the Krishna River Basin show a wide spatial variation across the basin. The observed EC values range from 70  $\mu\text{S}/\text{cm}$  to 84,660  $\mu\text{S}/\text{cm}$ , with an average value of 1,722  $\mu\text{S}/\text{cm}$ , indicating considerable heterogeneity in groundwater mineralization.

While several monitoring locations exhibit low to moderate EC values representing relatively fresh groundwater conditions, certain areas show very high EC values, suggesting elevated salinity and accumulation of dissolved ions.

The variation in EC across the basin can be attributed to both natural and anthropogenic factors. Weathering of rock-forming minerals, dissolution of salts, and longer groundwater residence time contribute to increased ionic concentration in hard rock terrains. In addition, intensive irrigation practices, evaporation under semi-arid climatic conditions, agricultural return flow, and urban wastewater influence may also lead to higher salinity levels in localized zones. Comparison with previous years (2019-2022) indicates that the average EC values in the basin remain within a similar range, although maximum values show significant fluctuations, reflecting localized hydrochemical processes and site-specific conditions. The spatial distribution map for 2023 highlights areas with relatively higher EC concentrations, which may require further attention due to potential impacts on drinking water quality and irrigation suitability. Overall, the EC distribution suggests that groundwater quality in the Krishna River Basin varies from fresh to highly mineralized conditions. Continuous monitoring and proper groundwater management practices are necessary in areas showing elevated EC values to prevent further deterioration of water quality.

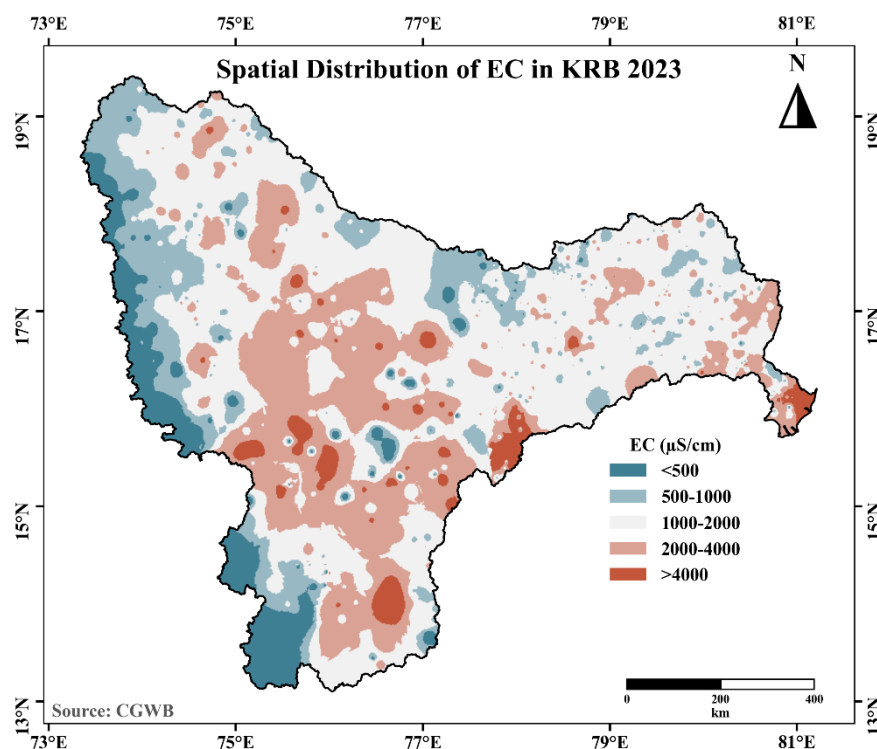


Figure 13 Spatial distribution of Electrical Conductivity in Krishna River Basin (2023)

### 4.2.3 Bicarbonates ( $\text{HCO}_3^-$ )

Bicarbonate ( $\text{HCO}_3^-$ ) is one of the dominant anions in natural groundwater systems and plays a crucial role in controlling the alkalinity and buffering capacity of water. It primarily originates from the dissolution of carbonate minerals such as calcite and dolomite, as well as from the weathering of silicate minerals under the influence of carbon dioxide in soil and groundwater. The interaction between carbon dioxide, water, and rock minerals leads to the formation of bicarbonate ions, making it a key indicator of water-rock interaction processes within aquifers. Although BIS (IS 10500:2012) does not specify a direct drinking water limit for bicarbonate, its concentration significantly influences pH, alkalinity, and the overall hydrogeochemical characteristics of groundwater.

The statistical analysis of groundwater data in the Krishna River Basin indicates that bicarbonate concentrations show substantial spatial and temporal variation. The average bicarbonate concentration ranges from 291 mg/L in 2020 to 441 mg/L in 2023, indicating moderate alkalinity conditions across the basin. Maximum concentrations reach as high as 3234 mg/L in 2023, suggesting strong geochemical enrichment in localized zones. Such high concentrations are often associated with prolonged groundwater residence time and intense water-rock interaction within hard rock aquifers.

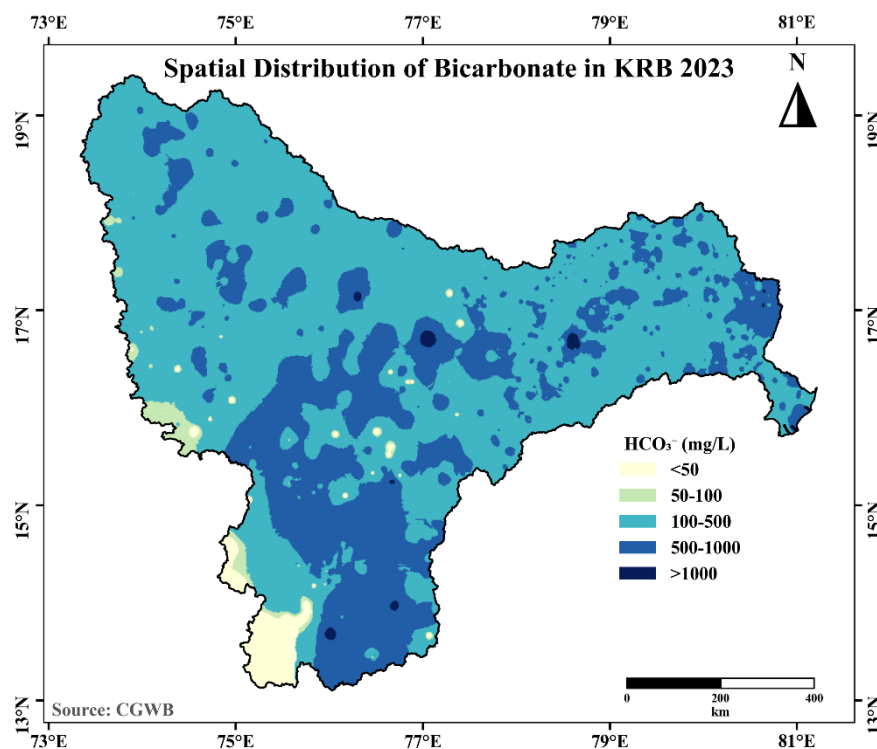


Figure 14 Spatial distribution of Bicarbonates in Krishna River Basin (2023)

The spatial distribution maps for 2019, 2022, and 2023 reveal that most parts of the basin fall within the 100-500 mg/L range, indicating moderate bicarbonate dominance typical of groundwater systems influenced by carbonate and silicate weathering. This range is widely observed across Pune, Satara, Sangli, Belagavi, Kalaburagi, Vikarabad, Nalgonda, and Guntur districts, reflecting relatively stable hydrochemical conditions. Higher bicarbonate concentrations are primarily observed in the central and southern parts of the basin, particularly in Raichur, Koppal, Ballari, and parts of Kurnool and Anantapur districts. Similar elevated zones are visible in parts of Nalgonda and Mahabubnagar regions of Telangana state, where groundwater shows strong interaction with host rock formations. These areas correspond with regions dominated by granitic and metamorphic terrains, where prolonged groundwater circulation promotes mineral dissolution and accumulation of bicarbonate ions. In contrast, relatively lower bicarbonate concentrations (<100 mg/L) are observed in parts of the western and southwestern highland regions, including Sindhudurg, Kolhapur, Chikkamagaluru, and Hassan districts. These areas generally receive higher rainfall and experience greater groundwater recharge, which dilutes dissolved ions and maintains comparatively lower alkalinity levels.

Overall, the distribution of bicarbonate in the Krishna River Basin reflects the influence of geological formations, climatic conditions, and groundwater flow dynamics. The dominance of bicarbonate in large parts of the basin indicates that groundwater chemistry is largely controlled by carbonate equilibrium reactions and silicate weathering processes. Elevated bicarbonate concentrations in certain regions may also contribute to increased alkalinity and hardness, affecting the suitability of groundwater for domestic and agricultural use. Therefore, continuous monitoring of bicarbonate levels is essential to better understand hydrogeochemical evolution and maintain sustainable groundwater management within the basin.

#### **4.2.4 Chlorides (Cl<sup>-</sup>)**

Chloride (Cl<sup>-</sup>) is one of the major anions present in groundwater and is widely used as an indicator of salinity and anthropogenic influence. Chloride mainly originates from dissolution of chloride-bearing minerals, evaporation processes, irrigation return flow, domestic wastewater discharge, and agricultural activities. Elevated chloride concentrations can affect the taste of water and increase corrosivity in distribution systems. As per IS 10500 drinking water standards, the desirable limit for chloride is 250 mg/L. Based on groundwater quality data for the year 2023 obtained from the Central Ground Water Board, chloride concentration

in the Krishna River Basin ranges from 3 mg/L to 41,665 mg/L, with an average value of 242 mg/L, indicating large spatial variability in groundwater salinity across the basin.

The spatial distribution map shows that most upstream districts of Maharashtra, including Pune, Satara, Sangli, Kolhapur, and Ahmednagar, are dominated by lower chloride concentrations (<250 mg/L), reflecting relatively fresh groundwater conditions and active recharge. Similarly, several districts of northern Karnataka such as Belagavi, Bagalkote, Dharwad, and Gadag also show predominantly low chloride levels. Moderate chloride concentrations (250-500 mg/L) are observed in parts of Kalaburagi, Yadgir, Raichur, and Koppal districts, indicating increasing mineralization likely influenced by semi-arid climatic conditions and groundwater-rock interaction. Higher chloride zones (500-1500 mg/L) appear as localized pockets in districts such as Mahabubnagar, Wanaparthy, Nagarkurnool, and Kurnool, suggesting localized salinity build-up possibly associated with irrigation practices and groundwater over-extraction. Very high chloride concentrations (>1500 mg/L) are mainly restricted to limited areas towards the downstream coastal region, particularly within Krishna district, and in few scattered pockets of central basin districts. These zones indicate localized salinity stress and may be influenced by evaporation effects, agricultural return flow, or anthropogenic inputs.

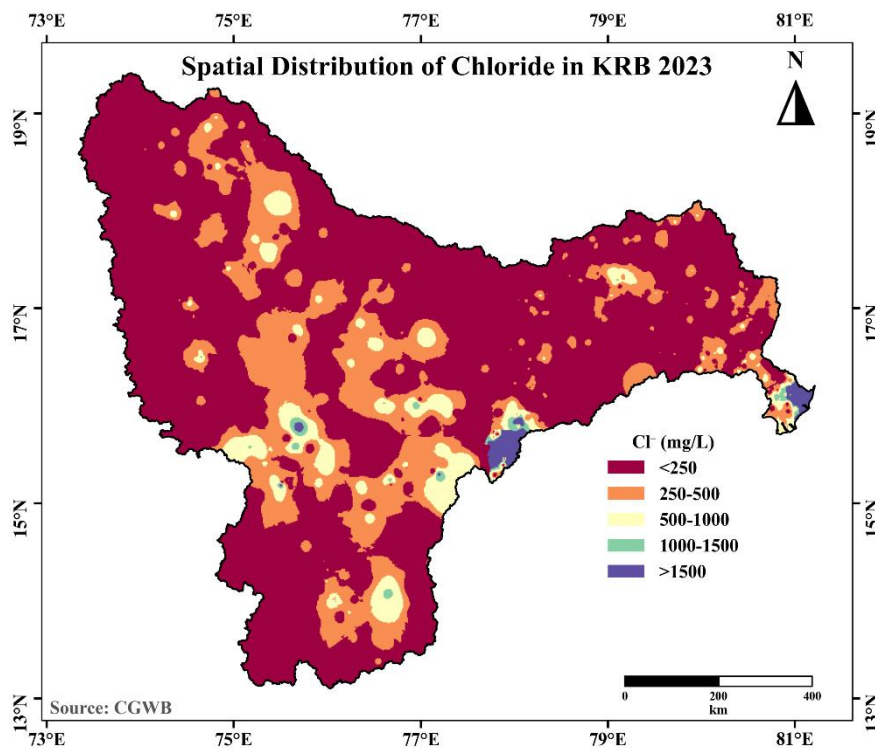


Figure 15 Spatial distribution of Chlorides in Krishna River Basin (2023)

Comparison with previous years (2019-2022) suggests that while average chloride concentration remains relatively stable across the basin, extreme values show significant variation due to localized hydro-chemical conditions. Overall, groundwater in most districts of the Krishna River Basin remains within acceptable limits with respect to chloride; however, districts showing elevated concentrations require continuous monitoring and targeted groundwater management strategies.

#### **4.2.5 Sulphates (SO<sub>4</sub><sup>2-</sup>)**

Sulphate (SO<sub>4</sub><sup>2-</sup>) is one of the major anions present in groundwater and contributes to total dissolved solids and overall mineralization. It is mainly derived from dissolution of sulphate-bearing minerals such as gypsum and anhydrite, oxidation of sulphide minerals, and anthropogenic sources including fertilizers and domestic or industrial wastewater. High sulphate concentration in drinking water may cause a laxative effect and can also contribute to scaling in pipelines and distribution systems. As per IS 10500, the desirable limit for sulphate in drinking water is 200 mg/L, with a permissible limit of 400 mg/L in the absence of alternate sources.

Based on groundwater quality data for the year 2023 obtained from the Central Ground Water Board, sulphate concentration in the Krishna River Basin ranges from 1 mg/L to 1,697 mg/L, with an average value of 101 mg/L. The basin-scale average indicates that groundwater is generally within the desirable limit; however, the large difference between minimum and maximum values reflects strong spatial variability.

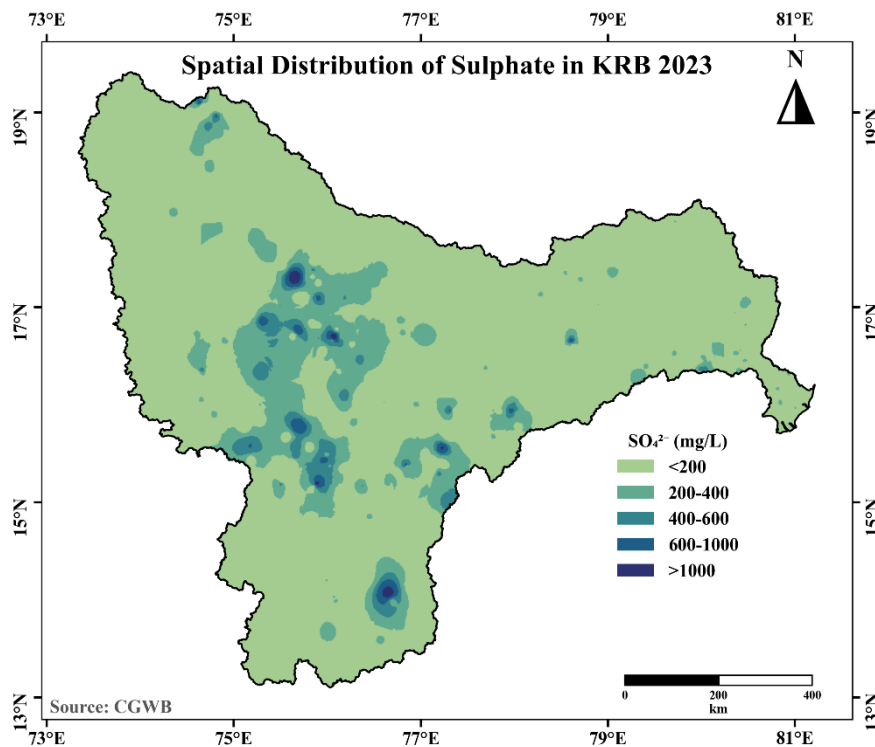


Figure 16 Spatial distribution of Sulphates in Krishna River Basin (2023)

The spatial distribution map for 2023 shows that most upstream districts of Maharashtra, including Pune, Satara, Sangli, Kolhapur, Ahmednagar, Beed, and Solapur, fall under the <200 mg/L category, indicating low sulphate concentration and relatively fresh groundwater conditions. Similarly, several districts in northern and western Karnataka such as Belagavi, Bagalkote, Dharwad, Gadag, and Vijayapura also exhibit predominantly low sulphate levels. Moderate sulphate concentrations (200-400 mg/L) are observed in parts of Kalaburagi, Yadgir, Raichur, Koppal, and Ballari districts. These areas are characterized by semi-arid climatic conditions and longer groundwater residence time, which may enhance mineral dissolution and concentration of dissolved ions. Higher sulphate zones (400-600 mg/L and 600-1000 mg/L) are more prominent in central portions of the basin, particularly within parts of Raichur, Koppal, Yadgir, and Mahabubnagar districts. These elevated concentrations may be influenced by rock-water interaction, agricultural return flow, and evaporation effects. Very high sulphate concentrations (>1000 mg/L) appear as isolated hotspots, especially in parts of Ballari district and limited pockets within Raichur and adjoining areas, indicating localized geochemical enrichment or anthropogenic impact. Such concentrations exceed the permissible drinking water limit and may pose health concerns if used continuously for consumption.

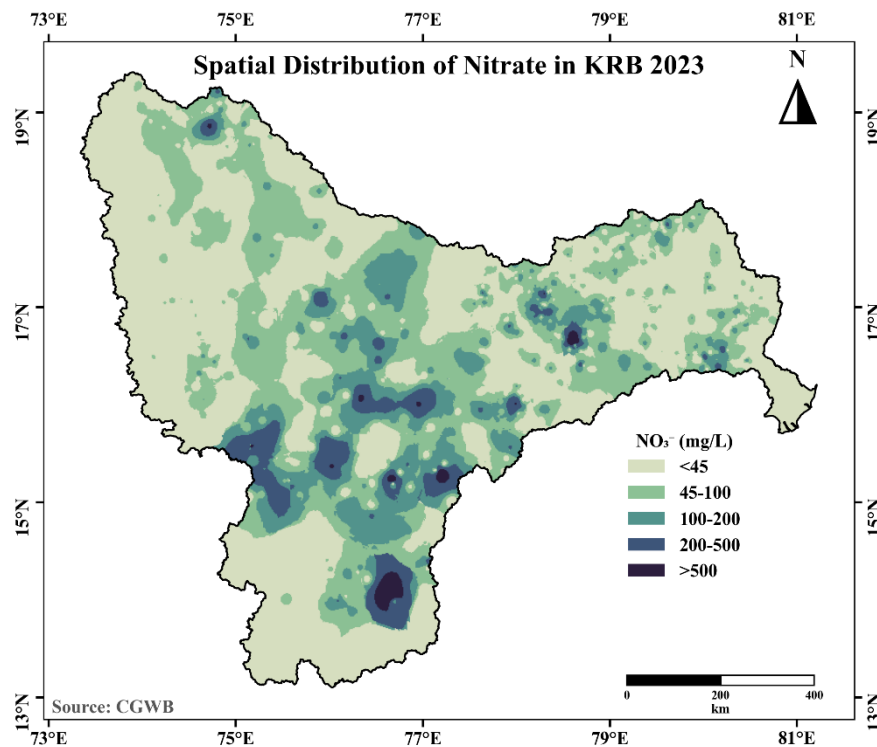
Comparison with previous years (2019-2022) shows that average sulphate concentration remains relatively stable at the basin scale, generally below 130 mg/L. However, fluctuations

in maximum values indicate that sulphate enrichment is localized rather than widespread. Overall, groundwater in most districts of the Krishna River Basin is within acceptable limits with respect to sulphate, but certain central and southern districts exhibit localized high concentrations that require periodic monitoring and appropriate groundwater management measures.

#### **4.2.6 Nitrates ( $\text{NO}_3^-$ )**

Nitrate ( $\text{NO}_3^-$ ) is one of the most critical groundwater quality parameters due to its direct impact on human health. It mainly originates from anthropogenic activities such as excessive use of nitrogen-based fertilizers, agricultural runoff, septic tank leakage, and domestic wastewater infiltration. Nitrate is highly mobile in groundwater and does not readily undergo attenuation, making it a reliable indicator of contamination. According to IS 10500, the desirable limit for nitrate in drinking water is 45 mg/L, beyond which it may pose health risks such as methemoglobinemia.

Based on groundwater quality data for the year 2023 obtained from the Central Ground Water Board, nitrate concentration in the Krishna River Basin ranges from 1 mg/L to 1,989 mg/L, with an average value of 58 mg/L. The average concentration exceeds the desirable limit, indicating that nitrate contamination is a significant concern in the basin. The spatial distribution map for 2023 shows that low nitrate concentrations (<45 mg/L) are mainly observed in upstream districts of Maharashtra such as Pune, Satara, and parts of Kolhapur and Ahmednagar, indicating relatively lesser anthropogenic influence. However, moderate to high nitrate concentrations (45-200 mg/L) are widely distributed across central parts of the basin.



*Figure 17 Spatial distribution of Nitrates in Krishna River Basin (2023)*

Elevated nitrate concentrations (200-500 mg/L) are prominently observed in districts such as Kalaburagi, Yadgir, Raichur, Koppal, Ballari, and parts of Dharwad and Gadag in Karnataka, as well as Mahabubnagar, Ranga Reddy, and Nalgonda in Telangana. These areas are characterized by intensive agricultural practices and groundwater exploitation, which contribute to nitrate leaching into aquifers. Very high nitrate concentrations (>500 mg/L) appear as distinct hotspots, particularly in Raichur, Koppal, Ballari, and Chitradurga districts, as well as in localized pockets of Nalgonda and surrounding Telangana districts. These zones indicate severe localized contamination, likely associated with excessive fertilizer application, poor sanitation infrastructure, and shallow aquifer vulnerability. Comparison with earlier years indicates that nitrate contamination has become more widespread and intensified in 2023, especially in central and southern parts of the basin. While earlier maps show scattered high-nitrate zones, the 2023 distribution reflects expansion of moderate to high concentration areas, suggesting increasing anthropogenic pressure on groundwater systems.

Overall, nitrate contamination is one of the major groundwater quality issues in the Krishna River Basin. Several districts, particularly in central Karnataka and parts of Telangana, fall under critical conditions and require immediate attention through controlled fertilizer use, improved sanitation, and regular groundwater quality monitoring.

#### 4.2.7 Total Hardness

Total Hardness (TH) is an important parameter that indicates the concentration of divalent cations, mainly calcium ( $\text{Ca}^{2+}$ ) and magnesium ( $\text{Mg}^{2+}$ ), in groundwater. Hardness is primarily caused by dissolution of carbonate, bicarbonate, and sulphate minerals present in aquifer materials. Based on hardness levels, water is generally classified as soft (<200 mg/L), moderately hard (200-500 mg/L), hard (500-1000 mg/L), and very hard (>1000 mg/L). Although hardness does not pose direct health risks, very hard water can cause scaling in pipes, reduced efficiency of soaps and detergents, and operational issues in industrial systems. As per Bureau of Indian Standards (IS 10500:2012), the desirable limit for total hardness is 200 mg/L, while the permissible limit in the absence of an alternate source is 600 mg/L.

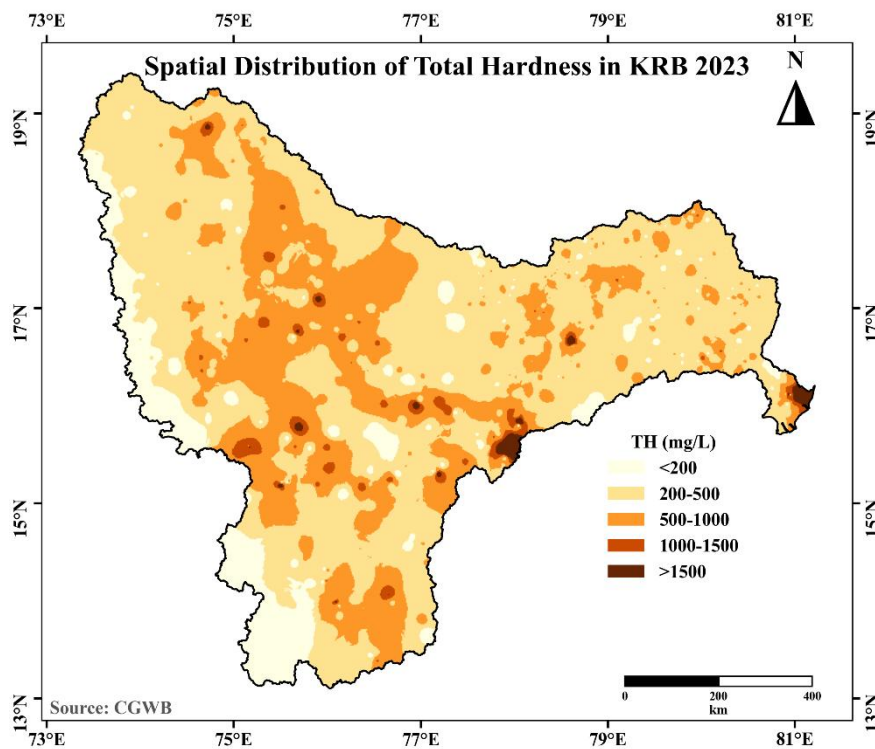


Figure 18 Spatial distribution of Total Hardness in Krishna River Basin (2023)

Based on groundwater quality data for the year 2023 obtained from the Central Ground Water Board, total hardness in the Krishna River Basin ranges from 20 mg/L to 7,050 mg/L, with an average value of 440 mg/L. The average value exceeds the desirable limit but remains within the permissible limit, indicating that groundwater in the basin is generally moderately hard to hard in nature.

The spatial distribution map for 2023 shows that lower hardness values (<200 mg/L), which fall within the desirable BIS limit, are observed in limited upstream regions of Maharashtra

such as Pune, Satara, and parts of Kolhapur, indicating relatively softer groundwater conditions associated with active recharge. Moderate hardness (200-500 mg/L), which exceeds the desirable limit but is still acceptable, dominates a large part of the basin, particularly in districts such as Sangli, Ahmednagar, Solapur, Belagavi, and parts of Telangana districts. Higher hardness values (500-1000 mg/L), exceeding both desirable and in many cases the permissible BIS limits, are widely distributed across central parts of the basin, especially in Vijayapura, Bagalkote, Kalaburagi, Yadgir, Raichur, Koppal, Ballari, and Mahabubnagar districts. These areas are characterized by hard rock aquifers and enhanced mineral dissolution. Very hard water conditions (>1000 mg/L), significantly exceeding the permissible BIS limit, are observed in localized hotspots, particularly in Koppal, Raichur, Ballari, Kurnool, and parts of Prakasam and Krishna districts, indicating severe hardness problems. Such water is generally unsuitable for direct domestic use without treatment.

Temporal comparison of spatial maps indicates that hardness levels have become more widespread and slightly intensified in 2023. This trend is supported by the increase in average TH values from 347 mg/L (2020) to 440 mg/L (2023), indicating increasing mineralization in groundwater. The high hardness observed in the basin is mainly attributed to dissolution of calcium and magnesium-bearing minerals, prolonged groundwater residence time, and evaporation effects under semi-arid conditions. Anthropogenic influences such as irrigation return flow may also contribute in certain areas. Overall, groundwater in the Krishna River Basin is predominantly moderately hard to very hard, with many districts exceeding the desirable BIS limit and some exceeding the permissible limit. These areas may require softening treatment before use for drinking and domestic purposes, along with continuous monitoring to manage groundwater quality.

#### **4.2.8 Calcium (Ca<sup>2+</sup>)**

Calcium (Ca<sup>2+</sup>) is one of the dominant cations in groundwater and plays a major role in controlling water hardness and hydrochemical characteristics. It is mainly derived from the dissolution of calcium-bearing minerals such as limestone, dolomite, gypsum, and silicate minerals present in aquifer formations. Calcium is essential for human health; however, higher concentrations may lead to scaling in pipes and reduce the suitability of water for domestic and industrial uses. As per Bureau of Indian Standards (IS 10500:2012), the desirable limit for calcium is 75 mg/L, and the permissible limit in the absence of an alternate source is 200 mg/L. Based on groundwater quality data for the year 2023 obtained from the Central Ground Water

Board, calcium concentration in the Krishna River Basin ranges from 2 mg/L to 1,513 mg/L, with an average value of 96 mg/L. The average value exceeds the desirable limit but remains within the permissible limit, indicating moderate calcium enrichment in groundwater across the basin.

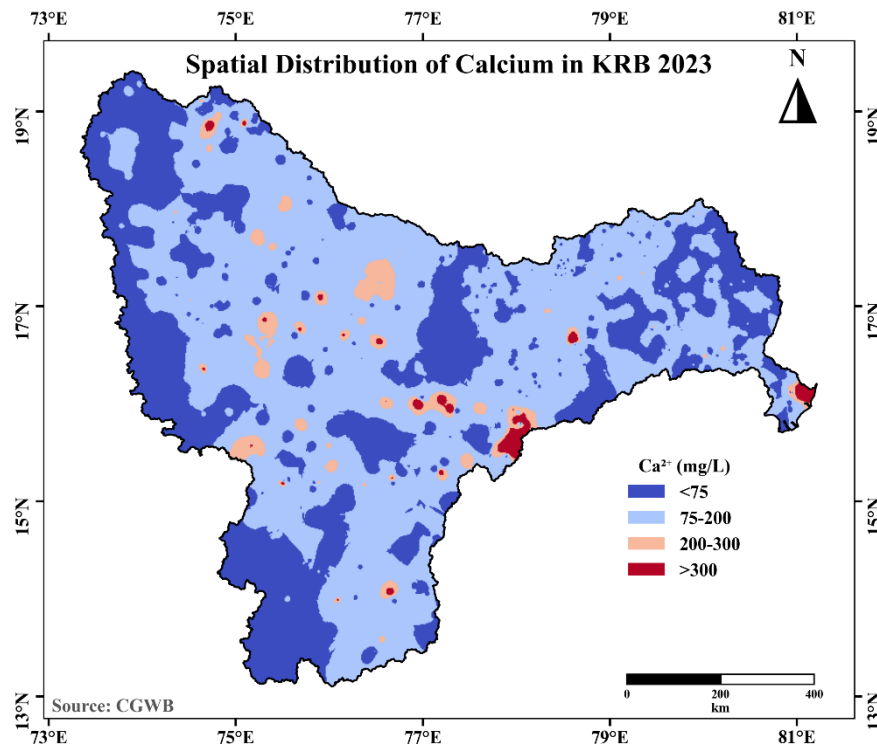


Figure 19 Spatial distribution of Calcium in Krishna River Basin (2023)

The spatial distribution map for 2023 shows that low calcium concentrations (<75 mg/L), within the desirable BIS limit, are dominant in upstream Maharashtra districts such as Pune, Satara, Kolhapur, and parts of Ahmednagar, as well as in western and southern Karnataka districts including Belagavi, Dharwad, Haveri, Chikkamagaluru, and Hassan, indicating relatively less mineralized groundwater conditions. Moderate calcium concentrations (75-200 mg/L), exceeding the desirable limit but within the permissible range, are widely distributed across central parts of the basin, particularly in districts such as Solapur, Vijayapura, Bagalkote, Kalaburagi, Yadgir, Raichur, Koppal, Ballari, and parts of Telangana districts. These areas reflect the influence of carbonate weathering and prolonged rock water interaction in hard rock aquifers. Higher calcium concentrations (>200 mg/L), exceeding the permissible BIS limit, are observed in localized pockets, especially in Raichur, Koppal, Ballari, Kurnool, Prakasam, Krishna, and parts of Nalgonda and Mahabubnagar districts. Very high concentrations (>300 mg/L) are particularly noticeable in parts of Kurnool and coastal Krishna district, indicating strong mineral dissolution and possible concentration effects due to semi-arid conditions and

groundwater exploitation. Temporal comparison of spatial maps indicates that calcium concentrations have slightly increased in extent and intensity in 2023. While earlier years show more scattered high-calcium zones, the 2023 map reflects expansion of moderate to high concentration areas, especially in central Karnataka and downstream Andhra Pradesh regions. This trend is consistent with the increase in average calcium concentration from 58 mg/L (2020) to 96 mg/L (2023).

The elevated calcium levels observed in the basin are mainly attributed to dissolution of carbonate and silicate minerals, longer groundwater residence time, and evaporation effects under semi-arid climatic conditions. The strong association between calcium and total hardness further confirms its role in controlling groundwater hardness in the basin. Overall, groundwater in the Krishna River Basin shows low to moderate calcium concentrations in most areas; however, several districts exceed the desirable BIS limit and localized zones exceed the permissible limit. These areas may require appropriate treatment and management measures for safe domestic use, along with regular monitoring to track changes in groundwater chemistry.

#### **4.2.9 Magnesium ( $Mg^{2+}$ )**

Magnesium ( $Mg^{2+}$ ) is one of the major cations present in groundwater and, along with calcium, contributes significantly to total hardness. It is mainly derived from the weathering and dissolution of ferromagnesian minerals, dolomite, and other magnesium-bearing rocks present in aquifer formations. Magnesium is an essential nutrient for human health; however, higher concentrations may impart a bitter taste to water and, in combination with sulphate, may produce a laxative effect. As per Bureau of Indian Standards (IS 10500:2012), the desirable limit for magnesium in drinking water is 30 mg/L, and the permissible limit in the absence of an alternate source is 100 mg/L.

Based on groundwater quality data for the year 2023 obtained from the Central Ground Water Board, magnesium concentration in the Krishna River Basin ranges from 1 mg/L to 796 mg/L, with an average value of 48 mg/L. The average concentration exceeds the desirable limit but remains within the permissible limit, indicating moderate magnesium enrichment in the basin. The spatial distribution map for 2023 shows that low magnesium concentrations (<30 mg/L), within the desirable BIS limit, are observed in upstream Maharashtra districts such as Pune, Satara, Kolhapur, and parts of Ahmednagar, as well as in southern and western Karnataka districts including Chikkamagaluru, Hassan, Shivamogga, and Uttara Kannada, indicating

relatively less mineralized groundwater. Moderate magnesium concentrations (30-100 mg/L), exceeding the desirable limit but within the permissible range, are widely distributed across the basin, particularly in districts such as Solapur, Vijayapura, Bagalkote, Kalaburagi, Yadgir, Raichur, Koppal, Ballari, and parts of Telangana districts. These areas reflect the influence of weathering of magnesium-rich minerals and longer groundwater residence time. Higher magnesium concentrations (100-200 mg/L), exceeding the permissible BIS limit, are observed in localized pockets, especially in Raichur, Koppal, Ballari, Dharwad, Gadag, and Kurnool districts. Very high concentrations (>200 mg/L) are particularly noticeable in parts of Kurnool district and coastal Krishna district, indicating strong mineral dissolution and possible concentration due to semi-arid conditions and groundwater over-extraction.

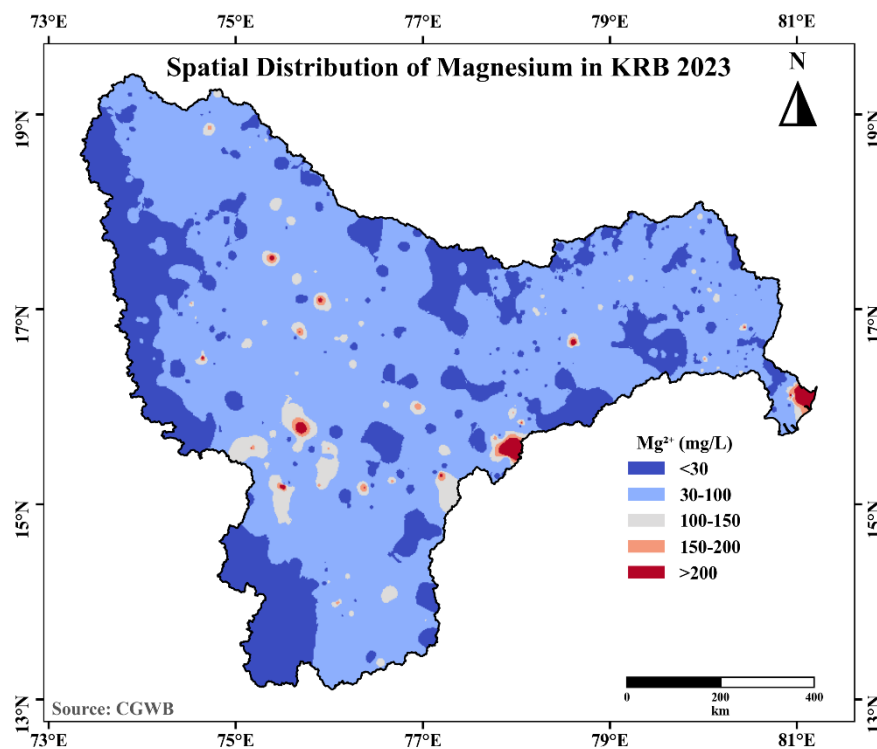


Figure 20 Spatial distribution of Magnesium in Krishna River Basin (2023)

Temporal comparison of spatial maps indicates that magnesium concentrations have slightly increased in intensity in certain localized areas in 2023, especially in central Karnataka and downstream Andhra Pradesh. However, the overall spatial pattern remains similar, with moderate concentrations dominating the basin. This is consistent with the gradual increase in average magnesium concentration from 38 mg/L (2021) to 48 mg/L (2023).

The elevated magnesium levels observed in the basin are mainly attributed to dissolution of dolomite and ferromagnesian minerals, prolonged rock-water interaction, and evaporation

effects under semi-arid climatic conditions. The strong association between magnesium and total hardness further confirms its contribution to groundwater hardness. Overall, groundwater in the Krishna River Basin shows low to moderate magnesium concentrations in most areas; however, several districts exceed the desirable BIS limit and localized zones exceed the permissible limit. These areas may require appropriate treatment and management strategies for safe domestic use, along with regular monitoring of groundwater quality.

#### **4.2.10 Sodium (Na<sup>+</sup>)**

Sodium (Na<sup>+</sup>) is a key alkali metal ion in groundwater that plays an important role in determining salinity and suitability of water, especially for irrigation purposes. Unlike calcium and magnesium, sodium is more associated with ion exchange processes, weathering of feldspar minerals, and anthropogenic inputs such as agricultural return flow and domestic wastewater. Elevated sodium levels in drinking water may affect taste and can be unsuitable for individuals with certain health conditions, while in irrigation water it may lead to soil sodicity and reduced permeability. As per Bureau of Indian Standards (IS 10500:2012), no specific desirable or permissible limit is prescribed for sodium in drinking water; however, concentrations above 200 mg/L are generally considered unsuitable for drinking based on taste and health considerations.

Groundwater data for 2023 obtained from the Central Ground Water Board show that sodium concentration in the Krishna River Basin varies widely from 3 mg/L to 22,437 mg/L, with an average value of 177 mg/L. While the average value is below 200 mg/L, the very high maximum concentration indicates strong localized salinity issues. The 2023 spatial pattern clearly shows that sodium enrichment is not uniform across the basin. Relatively low sodium concentrations (<200 mg/L) dominate in upstream regions such as Pune, Satara, Kolhapur, and parts of Ahmednagar, as well as in western Karnataka districts like Belagavi and Uttara Kannada, indicating comparatively fresh groundwater conditions with limited salinity influence. In contrast, moderate sodium levels (200-500 mg/L) are widespread across central parts of the basin, particularly in Vijayapura, Bagalkote, Kalaburagi, Yadgir, Raichur, Koppal, Ballari, and extending into Mahabubnagar and Nalgonda districts. This pattern suggests progressive mineralization and possible ion exchange processes, where calcium and magnesium are replaced by sodium in groundwater. Higher sodium concentrations (500-1000 mg/L) and very high concentrations (>1000 mg/L) are observed as distinct hotspots, especially in Kurnool district, coastal Krishna district, and parts of Raichur, Koppal, and Chitradurga.

These zones indicate strong salinity development, likely influenced by evaporation, irrigation return flows, and groundwater over-extraction in semi-arid regions.

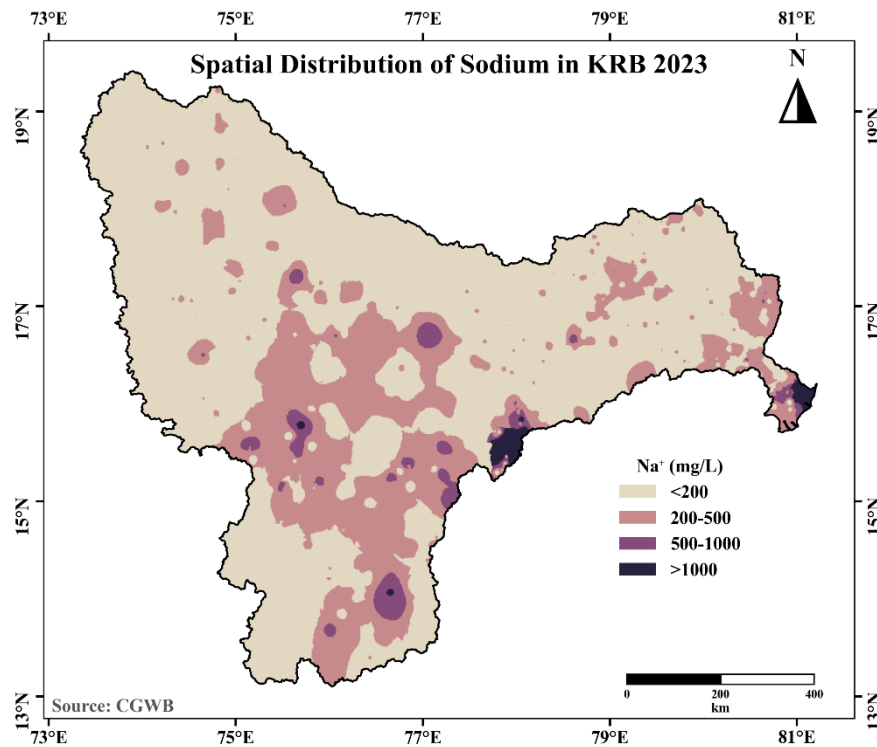


Figure 21 Spatial distribution of Sodium in Krishna River Basin (2023)

A comparison of spatial maps from 2019 to 2023 indicates a gradual expansion of sodium-affected areas, particularly in central Karnataka and downstream Andhra Pradesh. The 2023 map shows more continuous zones of moderate to high sodium concentration compared to earlier years, suggesting increasing salinization of groundwater in the basin.

From a hydrochemical perspective, the observed sodium distribution reflects the combined effect of rock-water interaction, cation exchange, evapotranspiration, and anthropogenic inputs. Areas with high sodium often coincide with regions showing high EC and TDS, indicating overall salinity increase. Overall, while a significant portion of the Krishna River Basin still shows acceptable sodium levels, several districts, particularly Raichur, Koppal, Ballari, Kurnool, and Krishna, fall under critical conditions. Groundwater from these areas may not be suitable for drinking and irrigation without appropriate treatment or management practices. Continuous monitoring and control of groundwater abstraction and agricultural inputs are necessary to prevent further salinity build-up.

#### 4.2.11 Potassium (K<sup>+</sup>)

Potassium ( $K^+$ ) is a minor cation in groundwater and usually occurs in low concentrations due to its tendency to be retained within soil matrices and clay minerals through ion-exchange processes. It is mainly derived from the weathering of potassium-bearing minerals such as feldspars and micas. In addition, anthropogenic inputs such as agricultural fertilizers, domestic wastewater, and irrigation return flows can also contribute to elevated potassium levels in groundwater. As per BIS (IS 10500:2012), no specific acceptable or permissible limit is prescribed for potassium; however, unusually high concentrations may indicate localized contamination.

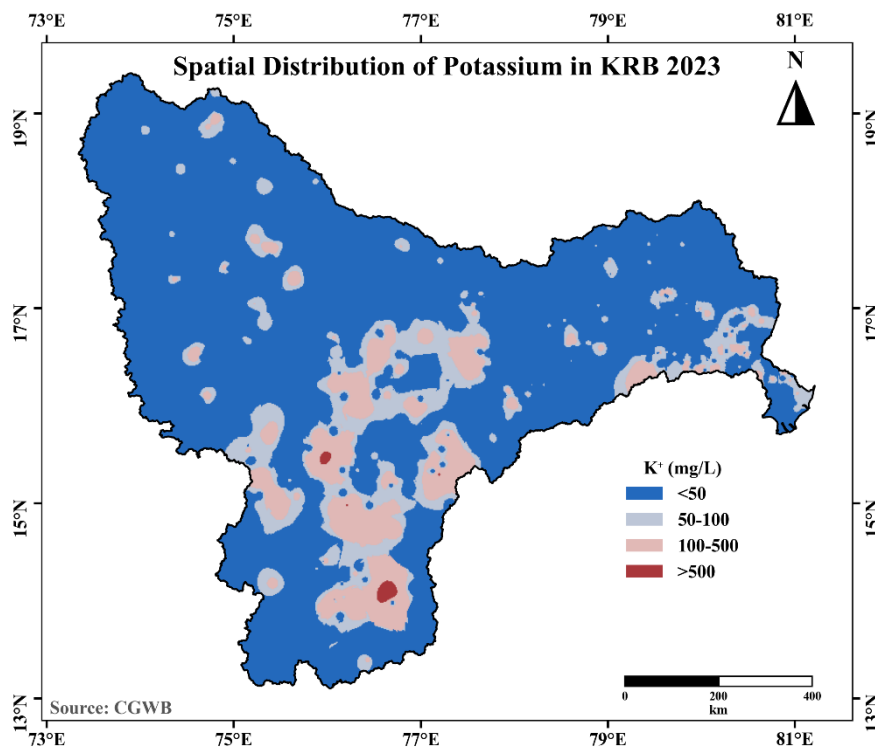


Figure 22 Spatial distribution of Potassium in Krishna River Basin (2023)

The statistical analysis of the dataset indicates that the average potassium concentration in the Krishna River Basin varies between 8.16 mg/L (2021) and 28.33 mg/L (2023), reflecting generally low background levels. However, the maximum concentrations show significant variability, reaching up to 1229 mg/L in 2023, which suggests the presence of localized hotspots with elevated potassium content. The spatial distribution maps reveal that a major portion of the basin, including districts such as Pune, Satara, Sangli, Kolhapur, Belagavi, and Raichur, is characterized by low potassium concentrations (<50 mg/L), indicating dominance of natural geochemical conditions and minimal external influence. Moderate concentrations in the range of 50-100 mg/L are observed in parts of Kalaburagi, Yadgir, Vikarabad, Nalgonda, and Guntur, which may be attributed to agricultural practices and fertilizer application.

Higher potassium concentrations (100-500 mg/L) are observed in localized pockets across Koppal, Ballari, Chitradurga, Kurnool, and Jogulamba Gadwal districts, suggesting the influence of intensive agriculture, irrigation return flows, and possible lithological contributions. Very high concentrations (>500 mg/L) are limited to isolated hotspots, particularly in Ballari, Chitradurga, and parts of Krishna district, indicating strong localized enrichment possibly due to excessive fertilizer usage or anthropogenic contamination. Overall, potassium distribution in the basin is highly heterogeneous and largely controlled by localized factors rather than regional hydrogeochemical processes. While most of the basin remains within low concentration ranges, the presence of isolated high-value zones highlights the need for site-specific monitoring and management, especially in agriculturally intensive regions.

#### **4.2.12 Fluorides (F<sup>-</sup>)**

Fluoride is one of the most significant groundwater quality parameters in the Krishna River Basin due to its strong linkage with human health and its predominantly geogenic origin. It is unique among water quality parameters because it is beneficial in small amounts but harmful at higher concentrations. As per BIS (IS 10500:2012), the desirable limit for fluoride in drinking water is 1.0 mg/L, while the permissible limit in the absence of an alternate source is 1.5 mg/L. Low concentrations may lead to dental caries, whereas prolonged consumption of water with fluoride above 1.5 mg/L can cause dental fluorosis and skeletal fluorosis.

The groundwater dataset indicates a wide variation in fluoride concentration across the basin. In 2023, fluoride ranges from 0.01 mg/L to as high as 6.44 mg/L, with an average value of 0.89 mg/L. Although the average concentration is within the desirable limit, the very high maximum values clearly indicate the presence of localized hotspots of severe contamination. Similar patterns are observed in previous years (2019 to 2022), suggesting that fluoride contamination is not a temporary phenomenon but a persistent hydrogeochemical characteristic of the basin.

The spatial distribution maps show that fluoride contamination is highly heterogeneous. Elevated concentrations (>1.5 mg/L and >2.5 mg/L) are mainly concentrated in the central and southern parts of the basin. High-risk zones are prominently observed in Raichur, Koppal, Ballari, Yadgir, and Kalaburagi districts of Karnataka. These zones extend eastward into Jogulamba Gadwal, Wanaparthy, Nagarkurnool, and Nalgonda districts of Telangana, which are already known fluoride-affected regions. In Andhra Pradesh, significant fluoride enrichment is observed in Kurnool and Prakasam districts, especially in localized pockets. In

contrast, most parts of Maharashtra (Pune, Satara, Sangli, Kolhapur) show relatively low fluoride concentrations, indicating comparatively safer groundwater conditions.

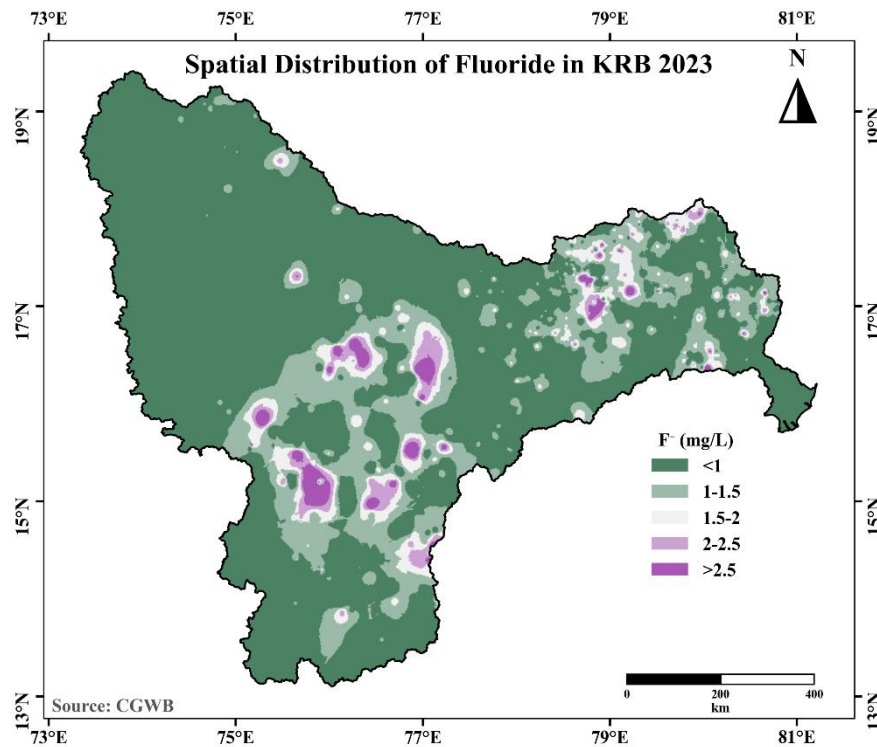


Figure 23 Spatial distribution of Fluorides in Krishna River Basin (2023)

The occurrence of high fluoride in these regions is mainly controlled by geological and hydrogeochemical factors. The basin is largely dominated by hard rock formations such as granites, gneisses, and basalts, which contain fluoride-bearing minerals like fluorite, apatite, hornblende, and biotite. Weathering and dissolution of these minerals release fluoride into groundwater. Additionally, alkaline pH conditions, high bicarbonate concentration, and long groundwater residence time enhance fluoride mobility. Anthropogenic activities such as excessive groundwater extraction, irrigation return flows, and use of phosphate fertilizers may further influence fluoride levels in certain areas.

From a public health perspective, fluoride contamination in the Krishna River Basin is a critical concern. Even though the basin-wide average concentration is within acceptable limits, a significant number of locations exceed the BIS permissible limit, exposing rural populations to the risk of fluorosis. Therefore, it is necessary to identify affected districts and habitations, promote regular monitoring, and implement mitigation strategies such as defluoridation techniques (e.g., Nalgonda technique, activated alumina), blending of water, and development of alternative safe water sources. In summary, fluoride distribution in the Krishna River Basin

reflects strong geogenic control with distinct regional hotspots. The issue is localized but severe, and requires targeted management interventions rather than basin-wide generalized solutions.

#### **4.2.13 Total Dissolved Solids (TDS)**

Total Dissolved Solids (TDS) represent the cumulative concentration of all dissolved salts present in groundwater. It is one of the most integrative indicators of water quality, reflecting the combined influence of geological formations, water-rock interaction, residence time, and anthropogenic inputs. According to BIS (IS 10500:2012), the desirable limit for TDS in drinking water is 500 mg/L, while the permissible limit in the absence of an alternate source is 2000 mg/L.

The dataset indicates considerable spatial variability of TDS across the Krishna River Basin. TDS values are not available for the year 2023, but the observed Electrical Conductivity (EC) values (average approx. 1722  $\mu\text{S}/\text{cm}$ ) suggest moderate to high mineralization in groundwater, consistent with elevated TDS levels in several parts of the basin. TDS values of previous year's show average TDS values of 927 mg/L (2019), 612 mg/L (2020), and 709 mg/L (2021), indicating that groundwater quality generally falls within the moderate salinity category, with localized zones exceeding permissible limits. The spatial distribution map of the year 2019 reveals a heterogeneous pattern. Low TDS values (<500 mg/L) are predominantly observed in the western and southwestern parts, particularly in Pune, Satara, Kolhapur, Sindhudurg, and parts of Chikkamagaluru and Hassan, indicating relatively fresh groundwater conditions. Moderate TDS levels dominate a large portion of the basin, including Belagavi, Sangli, Kalaburagi, Vikarabad, and parts of Telangana, reflecting typical water-rock interaction in hard rock aquifers. Higher TDS concentrations are observed in several localized pockets, especially in the central and southern regions. Notable high TDS zones include Raichur, Koppal, Ballari, and parts of Kurnool and Anantapur, as well as isolated patches in Guntur and coastal Andhra Pradesh. These areas correspond well with zones of high EC, sodium, and chloride, indicating salinity enrichment and possible evaporative concentration effects.

The elevated TDS in these regions can be attributed to multiple factors. Geogenically, prolonged water-rock interaction in granitic and basaltic terrains leads to dissolution of minerals contributing to dissolved solids. In semi-arid regions, high evaporation rates further concentrate salts in groundwater. Anthropogenic influences such as intensive irrigation, return

flow from agricultural fields, and over-extraction of groundwater also play a significant role in increasing TDS levels.

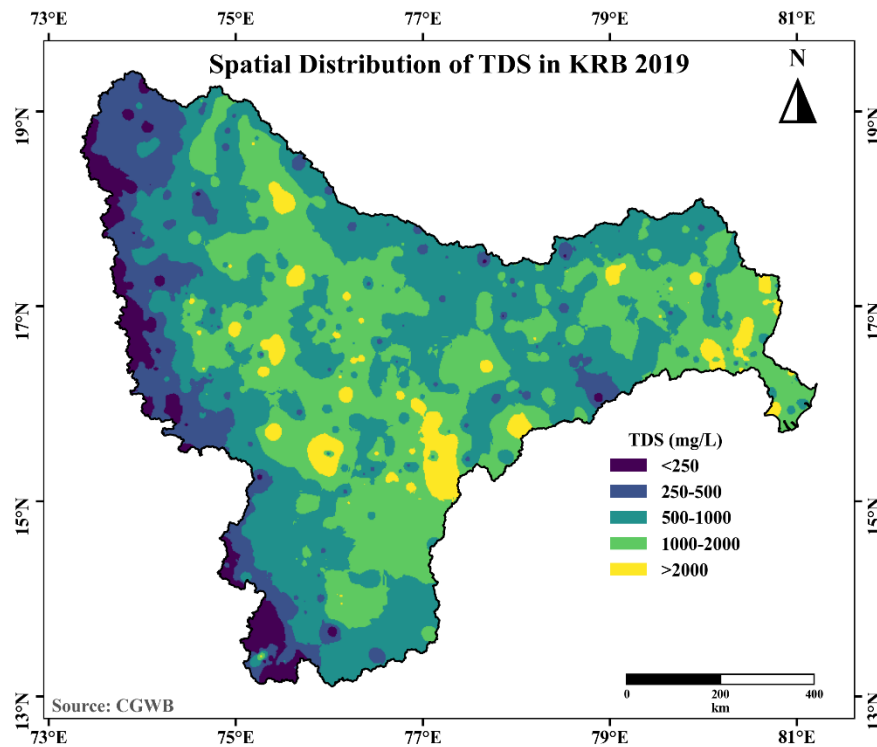


Figure 24 Spatial distribution of Total Dissolved Solids in Krishna River Basin (2019)

From a usability perspective, water with TDS less than 500 mg/L is generally considered excellent, while 500-1000 mg/L is acceptable. However, water exceeding 1000 mg/L may cause taste issues, scaling in pipes, and reduced suitability for drinking. At levels above 2000 mg/L, groundwater becomes unsuitable for drinking and may also affect agricultural productivity due to soil salinization. Overall, TDS distribution in the Krishna River Basin indicates that while a substantial portion of the basin has acceptable groundwater quality, there are critical pockets of high salinity that require attention. These areas need targeted management strategies such as controlled groundwater abstraction, improved irrigation practices, and artificial recharge to dilute dissolved solids.

### 4.3 Groundwater Quality Index (GWQI)

Groundwater Quality Index (GWQI) is an effective tool used to evaluate the overall suitability of groundwater for drinking purposes by integrating multiple physico-chemical parameters into a single numerical value. The index simplifies complex groundwater quality data and helps in understanding spatial variation in water quality conditions across large regions. In the present

study, GWQI was used to assess the groundwater quality status of the Krishna River Basin for the years 2019 and 2023.

The GWQI classification adopted in this study categorizes groundwater into five classes: excellent (<25), good (25-50), poor (50-75), very poor (75-100), and unsuitable for drinking (>100). The spatial distribution maps of GWQI reveal considerable variation in groundwater quality across different parts of the basin and indicate the influence of both natural hydrogeochemical processes and anthropogenic activities.

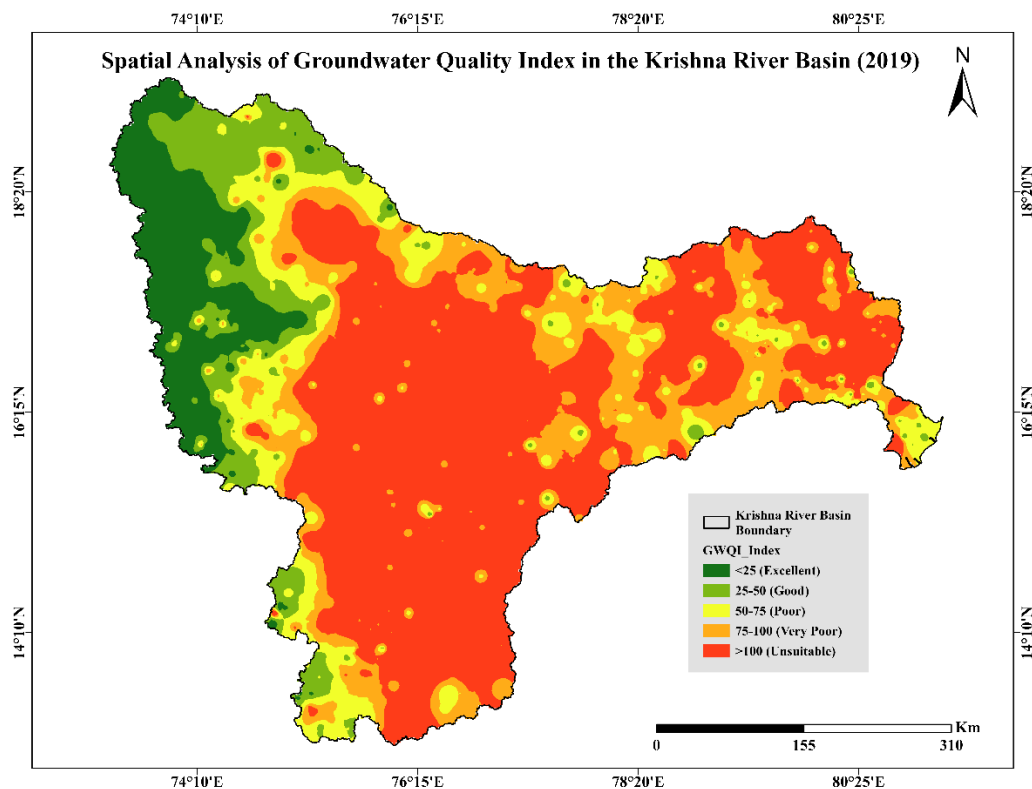


Figure 25 Spatial distribution of GWQI in Krishna River Basin during 2019

The 2019 GWQI map shows that a large part of the central and eastern regions of the Krishna River Basin was dominated by the “unsuitable” category (GWQI >100). These regions include several parts of northern Karnataka, Telangana, and Andhra Pradesh. Moderate groundwater quality conditions, represented by poor to very poor categories, were observed surrounding these highly deteriorated zones. In contrast, comparatively better groundwater quality was observed mainly in the western part of the basin, especially near the Western Ghats region of Maharashtra and parts of southwestern Karnataka, where groundwater falls under excellent to good categories. The better water quality in these areas may be associated with higher rainfall, comparatively lower groundwater mineralization, and reduced anthropogenic stress.

The spatial pattern observed in 2019 indicates that groundwater deterioration was closely associated with elevated concentrations of dissolved ions such as fluoride, sodium, bicarbonate, total dissolved solids, and hardness-producing constituents. Semi-arid climatic conditions, intensive groundwater extraction, agricultural activities, and geogenic weathering processes likely contributed to the higher GWQI values in central and eastern parts of the basin.

The GWQI map for 2023 indicates noticeable spatial changes in groundwater quality conditions across the basin. Although some regions still remain under the unsuitable category, the distribution of poor and very poor groundwater quality zones became more heterogeneous compared to 2019. Certain areas in the northwestern and western parts of the basin showed improvement, with expansion of good and moderate quality groundwater zones. However, extensive unsuitable groundwater regions were still observed in central Karnataka and eastern parts of Telangana and Andhra Pradesh.

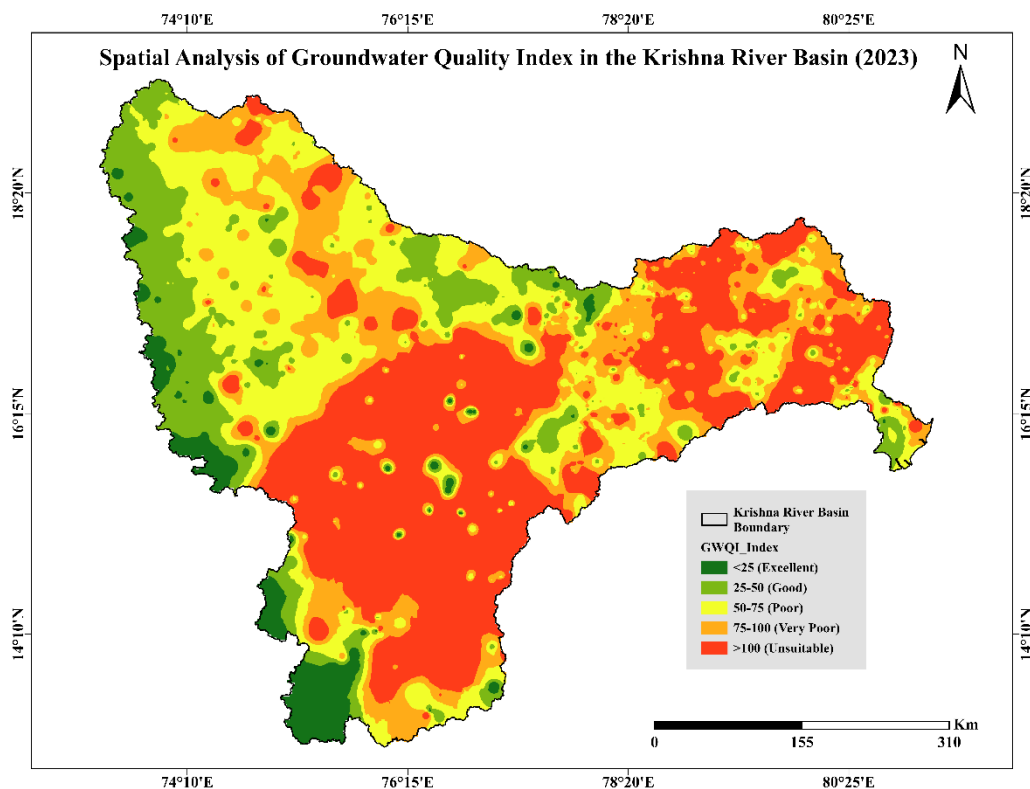


Figure 26 Spatial distribution of GWQI in Krishna River Basin during 2023

The persistence of high GWQI values in these regions suggests continuing groundwater quality stress due to both natural and anthropogenic factors. Geogenic sources such as weathering of fluoride-bearing and carbonate-rich rocks, along with evaporation under semi-arid climatic conditions, may contribute significantly to groundwater mineralization. In addition,

agricultural return flows, excessive fertilizer application, untreated domestic wastewater discharge, and over-exploitation of groundwater can further deteriorate groundwater quality.

Comparison between 2019 and 2023 indicates that groundwater quality in the Krishna River Basin remains a major concern, particularly in the middle and downstream regions of the basin. The spatial expansion of poor and unsuitable groundwater quality zones in some areas highlights the need for continuous groundwater quality monitoring and implementation of sustainable groundwater management practices. Measures such as controlled groundwater abstraction, artificial recharge, improved wastewater treatment, and regulation of agricultural chemical usage may help in reducing groundwater quality deterioration in vulnerable regions.

Overall, the GWQI analysis demonstrates that only limited portions of the basin possess groundwater of excellent quality, whereas a substantial area shows groundwater unsuitable for direct drinking purposes without treatment. The study emphasizes the importance of integrated groundwater quality management for ensuring long-term water security in the Krishna River Basin.

## **5. Summary and Recommendations**

### **5.1 Summary**

The present study provides a comprehensive assessment of the physico-chemical and biological characteristics of surface water and groundwater in the Krishna River Basin using secondary data collected from the Central Pollution Control Board (CPCB) and Central Ground Water Board (CGWB). Surface water quality assessment was carried out using monitoring data from the Krishna River and its major tributaries, including the Bhima, Tungabhadra, Panchaganga, Malaprabha, Bhadra, and Musi rivers, while groundwater quality assessment was performed using CGWB monitoring data for the period 2019-2023.

The analysis of surface water quality indicates considerable spatial and temporal variation across the basin. Parameters such as pH and dissolved oxygen generally remained within acceptable limits at many monitoring stations; however, elevated values of electrical conductivity, biochemical oxygen demand, nitrate, faecal coliforms, and total coliforms were observed at several locations, particularly in urban and downstream stretches. The Bhima River and Musi River were identified as the most polluted tributaries due to strong influence of untreated sewage discharge, urban runoff, and industrial activities. In contrast, tributaries such as the Bhadra and Malaprabha rivers showed comparatively better water quality conditions.

The Water Quality Index (WQI) analysis revealed that water quality conditions in the Krishna River Basin vary from good to unsuitable for direct use. Several upstream regions showed comparatively better water quality, whereas downstream stretches and urban-influenced tributaries exhibited deteriorated conditions. The Musi River was identified as one of the major contributors to river water quality degradation in the basin.

Groundwater quality assessment showed significant spatial variability in hydrochemical characteristics across the basin. Most groundwater samples exhibited neutral to slightly alkaline pH conditions. However, elevated concentrations of electrical conductivity, total dissolved solids, hardness, sodium, chloride, nitrate, and fluoride were observed in several regions, particularly in central and downstream parts of the basin. Groundwater quality deterioration was more prominent in semi-arid regions influenced by prolonged water-rock interaction, salinity development, agricultural activities, and excessive groundwater extraction.

The spatial distribution maps indicate that groundwater quality problems are particularly severe in parts of Karnataka, Telangana, and Andhra Pradesh, including districts such as Raichur, Koppal, Ballari, Kurnool, Mahabubnagar, and Nalgonda. Fluoride contamination was identified as one of the major groundwater quality concerns in the basin, with several locations exceeding the permissible BIS limit for drinking water. Similarly, elevated nitrate concentrations in some regions indicate possible influence of agricultural runoff and domestic wastewater contamination.

Groundwater Quality Index (GWQI) analysis indicates that a substantial portion of the basin falls under poor to unsuitable categories for drinking purposes. While upstream regions of Maharashtra generally show comparatively better groundwater quality, many central and downstream regions exhibit deteriorated groundwater conditions associated with salinity, hardness, and fluoride enrichment.

Overall, the study highlights that water quality in the Krishna River Basin is strongly influenced by both natural hydrogeochemical processes and anthropogenic activities. Increasing urbanization, agricultural intensification, untreated wastewater discharge, and over-exploitation of groundwater are major factors contributing to water quality deterioration in the basin.

## 5.2 Recommendations

Based on the findings of the present study, the following recommendations are proposed for sustainable management and improvement of water quality in the Krishna River Basin:

- Continuous and systematic monitoring of both surface water and groundwater quality should be strengthened across the basin, particularly in identified pollution hotspot regions.
- Untreated domestic sewage and industrial effluents are major contributors to river pollution, especially in urban tributaries such as the Musi River. Expansion and proper operation of sewage treatment plants (STPs) and effluent treatment plants (ETPs) are necessary to reduce pollutant loads entering river systems.
- Excessive application of fertilizers and agrochemicals should be minimized through promotion of sustainable agricultural practices, precision farming, and integrated nutrient management to reduce nitrate contamination in both surface water and groundwater.
- Artificial recharge structures, rainwater harvesting systems, and watershed management practices should be promoted to improve groundwater recharge and reduce groundwater depletion and salinity development in semi-arid regions.
- Districts showing elevated fluoride concentrations require special attention. Regular monitoring, installation of defluoridation units, and provision of alternative safe drinking water sources should be prioritized in fluoride-affected villages.
- Tributaries such as the Musi and Bhima rivers require targeted pollution control measures due to severe organic and microbial contamination associated with urban discharge and industrial activities.
- Effective management of water resources in the Krishna River Basin requires integrated basin-scale planning involving surface water, groundwater, land use, wastewater management, and ecological conservation.
- Awareness programs should be conducted to educate local communities regarding water conservation, pollution prevention, safe sanitation practices, and sustainable groundwater use.
- GIS-based water quality mapping and regular preparation of Water Quality Index (WQI) and Groundwater Quality Index (GWQI) maps should be continued for identification of pollution hotspots and planning of mitigation measures.

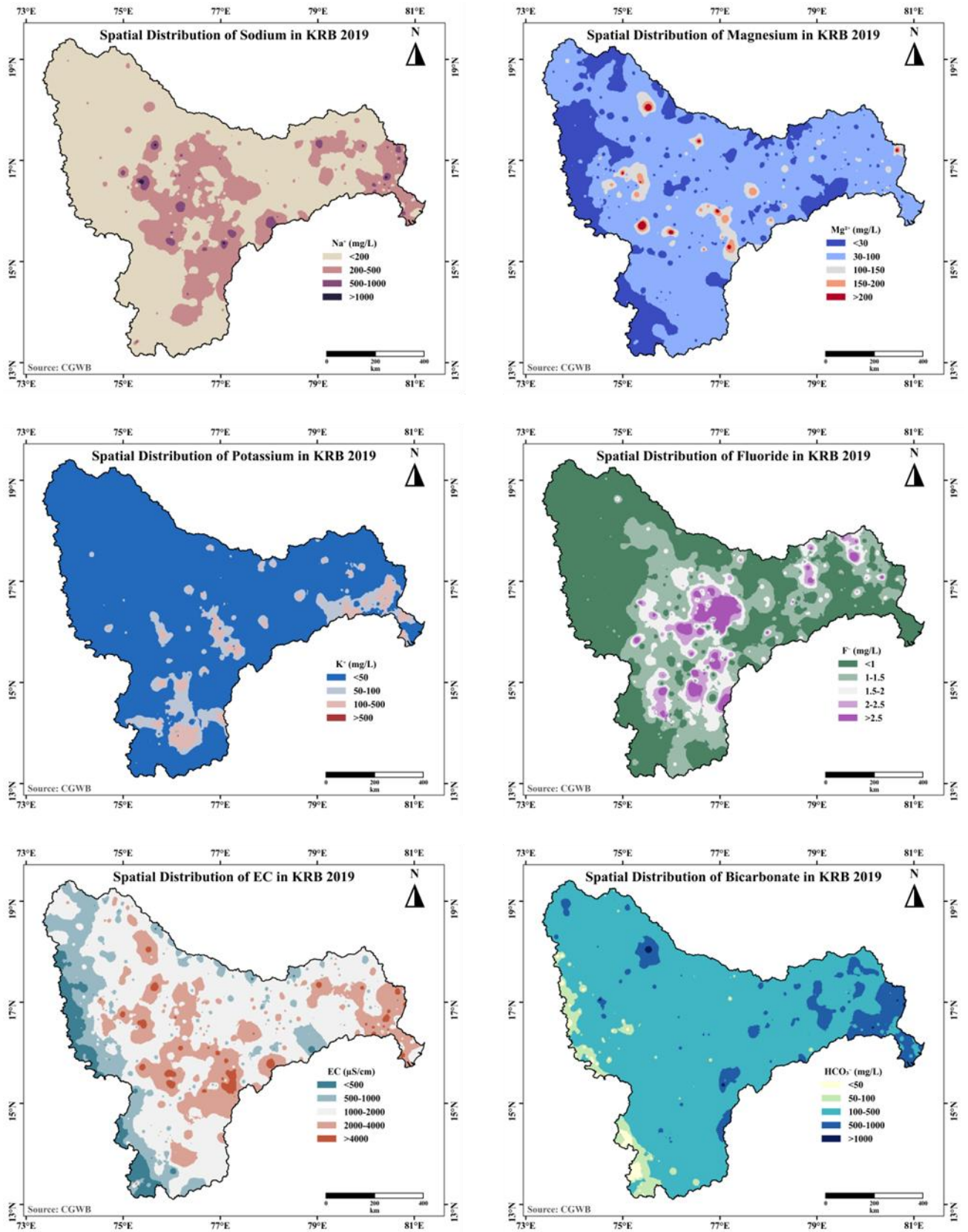
- Strict enforcement of environmental regulations and periodic review of industrial discharge standards are necessary to reduce pollution pressure on river systems and groundwater resources.

The present study provides important baseline information regarding the water quality status of the Krishna River Basin and can support future planning, pollution control strategies, and sustainable water resource management initiatives within the basin.

## References:

1. Avvannavar, S. M., & Shrihari, S. J. E. M. (2008). Evaluation of water quality index for drinking purposes for river Netravathi, Mangalore, South India. *Environmental monitoring and assessment*, 143(1), 279-290.
2. BIS IS Code 10500:2012 reaffirmed 2023
3. Bora, M., & Goswami, D. C. (2017). Water quality assessment in terms of water quality index (WQI): case study of the Kolong River, Assam, India. *Applied Water Science*, 7(6), 3125-3135.
4. Brown, R. M., McClelland, N. I., Deininger, R. A., & Tozer, R. G. (1970). A water quality index-do we dare. *Water and sewage works*, 117(10).
5. DEQ (2003) The Oregon Department of Environmental Quality. <http://www.deq.state.or.us/lab/WQM/WQI/Wqimain.html>
6. <https://cpcb.nic.in/water-quality-criteria/>
7. Leo ML, Dekkar M (2000) Hand book of water analysis (1–25,115–117, 143, 175, 223–226, 261, 273, 767). Marcel Dekker, New York.
8. Sawyer CN, Mc Carthy PL, Parkin GF (1994) Chemistry for environmental engineering, 4th edn. Mc Graw-Hill International Edition, New York, pp 365–577.
9. Shah, K. A., & Joshi, G. S. (2017). Evaluation of water quality index for River Sabarmati, Gujarat, India. *Applied water science*, 7(3), 1349-1358.

## Annexure



*Figure 27 Spatial distribution of groundwater quality parameters during 2019*

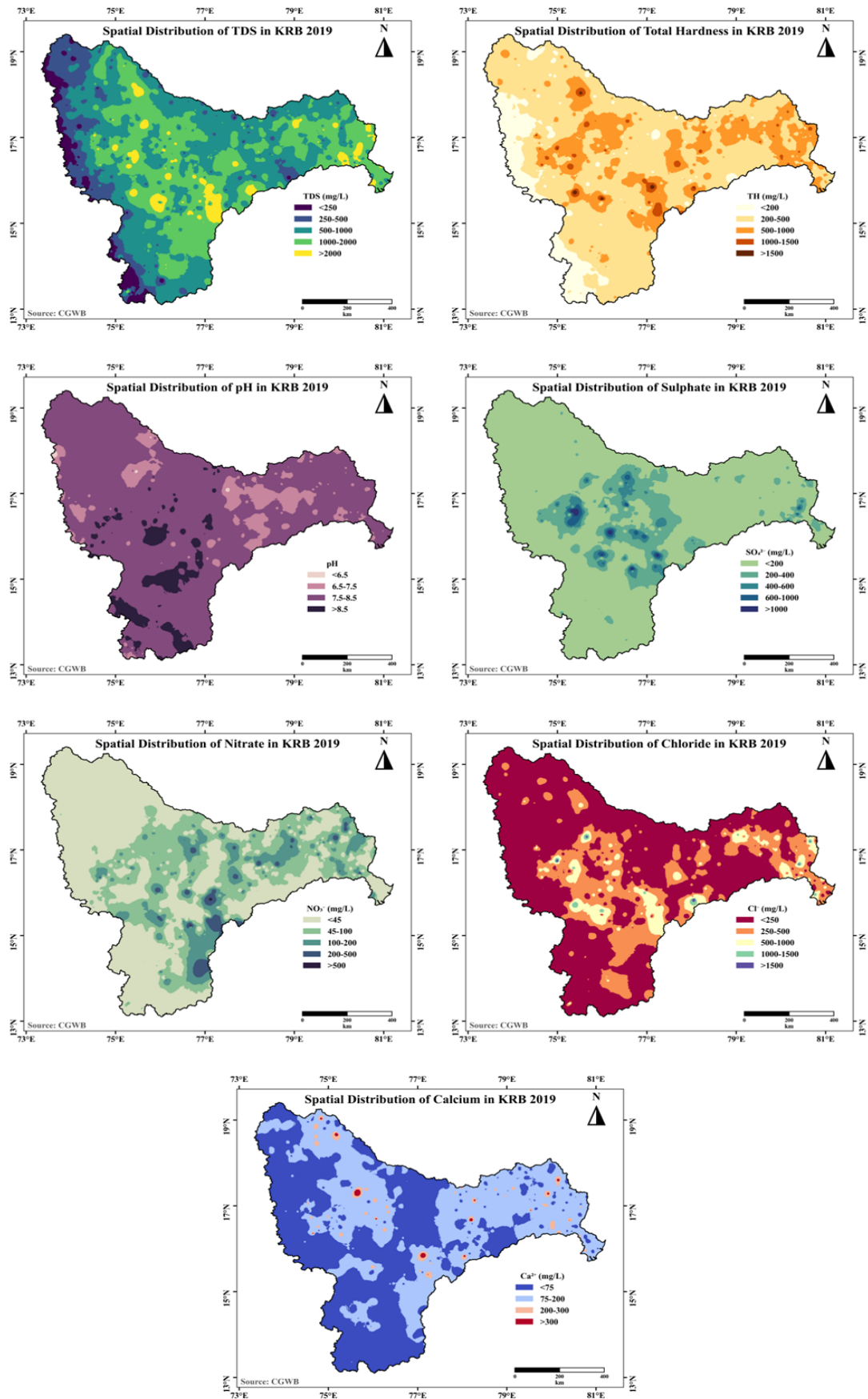


Figure 28 Spatial distribution of groundwater quality parameters during 2019

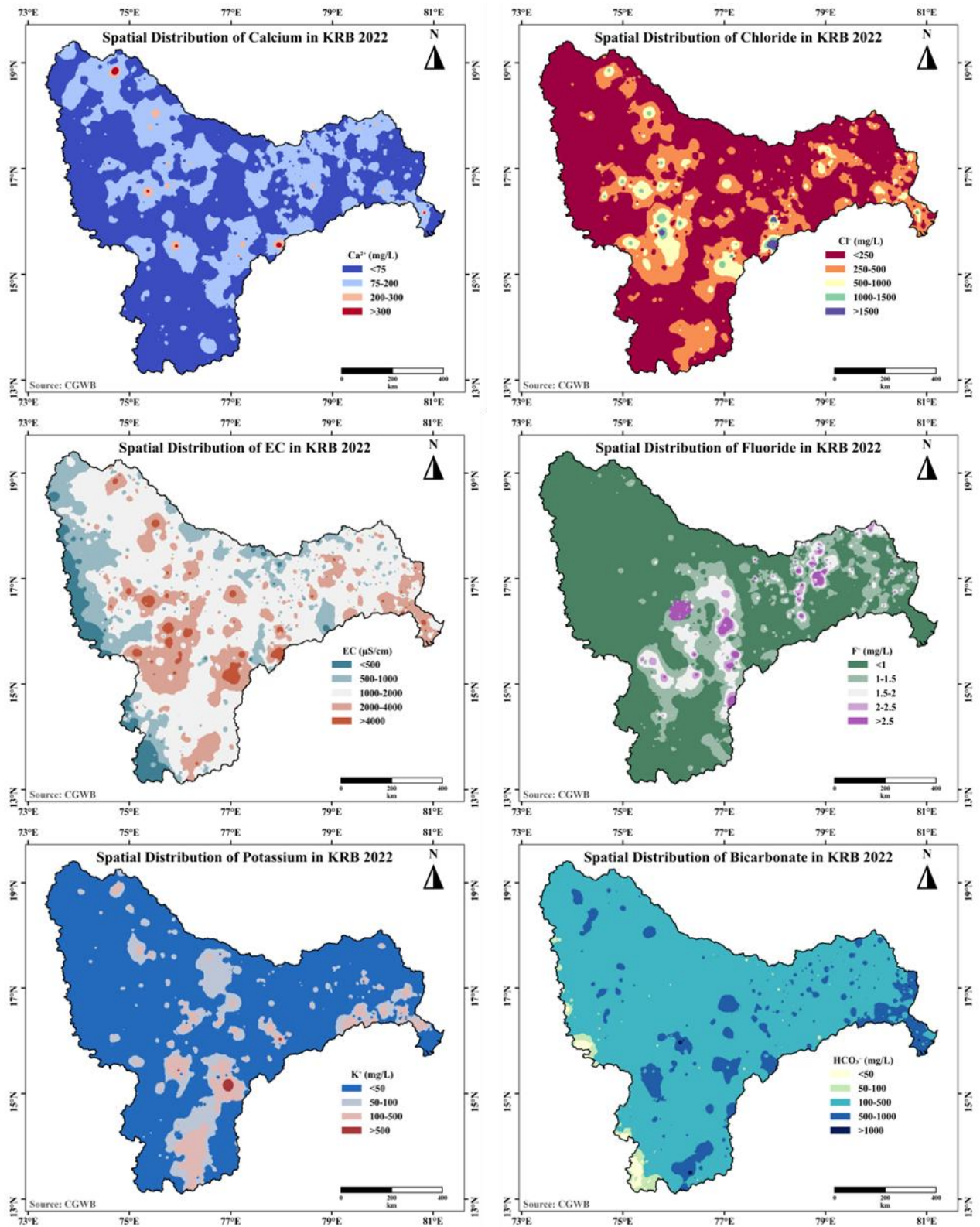


Figure 29 Spatial distribution of groundwater quality parameters during 2022

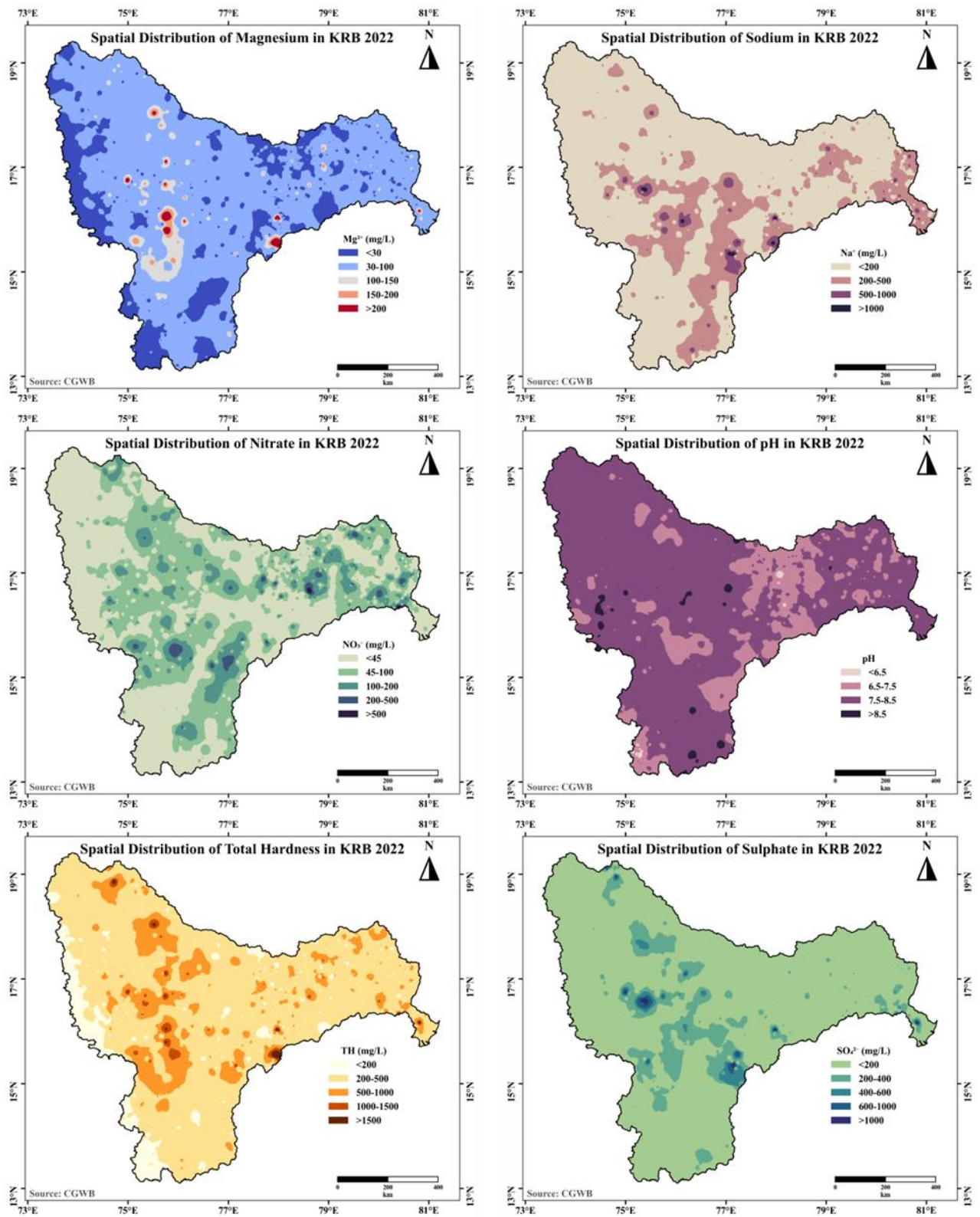


Figure 30 Spatial distribution of groundwater quality parameters during 2022

Table 1S. The average annual temperature concertation (°c) along the Krishna River at different monitoring stations (2018-2023)

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1153	Krishna River at Rajapur Weir, Village- Rajapur, Taluka- Shirol, District- Kolhapur.	Maharashtra	Monthly	16.6301	74.6639	21	24	27	31	27	26
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.2953	74.1888	26	26	26	26	26	28
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	22	23	24	26	27	18
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801	25	25	26	28	29	28
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903	21	25	27	30	28	26
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913	25	26	26	26	26	28
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633	23	23	24	26	24	26
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633	23	22	24	27	26	28
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707	30	30	31	29	29	30
10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213	28	25	27	28	29	29
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797	27	26	27	27	27	28
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627	27	29	29	29	29	28
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566	29	28	28	28	30	30
14	2781	Krishna at D/S aof Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999	33	31	31	29	32	30
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789	28	28	28	25	27	27
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Monthly	16.0019	78.365	24	22	25	26	25	24
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.3388	77.6102	28	28	28	26	29	26
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.6947	79.6899	24	21	21	20	19	21
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.8019	80.1296	26	25	26	27	26	26
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.5826	80.3435	22	21	24	23	23	24
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.4925	80.6408	26	25	23	26	26	24
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.0879	78.8902	23	20	24	25	24	24
23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near Avani-gadda(V), Krishna District	Andhra Pradesh	Monthly	16.0001	81.0791	27	28	26	26	26	27

Table 2S. The average annual Dissolved oxygen concentration (mg/L) along the Krishna River at different monitoring stations (2018-2023)

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1153	Krishna River at Rajapur Weir, Village- Rajapur, Taluka- Shirol, District- Kolhapur.	Maharashtra	Monthly	16.6301	74.6639	6.15	6.40	6.45	6.50	6.40	6.45
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.2953	74.1888	5.20	5.15	5.28	5.40	5.65	5.70
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	6.65	6.10	5.98	5.85	6.50	6.50
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801	5.75	6.35	6.03	5.70	6.60	6.80
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903	6.40	6.50	6.60	6.70	6.20	6.50
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913	5.00	5.05	5.33	5.60	5.60	5.70
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633	5.25	5.05	5.43	5.80	5.60	5.70
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633	5.45	5.20	5.60	6.00	5.45	5.50
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707	8.35	7.70	7.70	6.95	7.20	7.40
10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213	6.95	7.80	7.60	6.65	7.70	7.30
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797	7.15	7.55	7.20	6.45	7.30	7.40
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627	7.70	7.40	7.40	7.50	7.90	7.50
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566	7.30	7.10	7.40	7.30	7.70	7.30
14	2781	Krishna at D/S aof Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999	8.25	7.70	7.55	6.90	6.60	7.10
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789	5.20	5.10	5.95	5.20	5.85	5.70
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kunool	Andhra Pradesh	Monthly	16.0019	78.365	6.60	6.50	5.70	5.80	5.95	5.70

17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.338 8	77.610 2	5.30	5.35	5.95	5.3 0	5.75	5.6 5
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.694 7	79.689 9	6.90	6.65	6.50	6.1 0	6.20	6.3 0
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.801 9	80.129 6	6.95	7.25	7.20	7.3 0	7.05	7.4 0
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.582 6	80.343 5	6.90	7.25	7.25	7.2 5	7.30	7.3 0
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.492 5	80.640 8	7.10	7.20	7.25	7.1 5	7.30	7.4 5
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.087 9	78.890 2	6.70	6.20	6.00	5.8 0	5.95	5.7 5
23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near Avanigadda(V), Krishna District	Andhra Pradesh	Monthly	16.000 1	81.079 1	6.55	5.45	4.45	5.5 0	6.50	6.5 0

Table 3S. The average annual pH along the Krishna River at different monitoring stations (2018-2023)

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1153	Krishna River at Rajapur Weir, Village- Rajapur, Taluka-Shirol, District- Kolhapur.	Maharashtra	Monthly	16.630 1	74.6639	7.3 5	7.6 5	7.6 0	7.5 5	7.7 0	8.1 0
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.295 3	74.1888	8.0 0	7.9 0	7.9 7	8.0 0	8.1 0	7.8 0
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	7.5 0	7.7 0	7.8 2	7.9 0	8.0 5	8.0 5
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.029 3	74.3801	7.4 0	7.7 0	7.7 8	7.8 5	8.1 0	8.2 0
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.681 4	74.5903	7.3 0	7.5 0	7.5 3	7.5 5	7.7 5	8.1 5
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.949 3	73.8913	8.0 5	7.9 0	7.9 3	7.9 5	8.0 5	7.8 0
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.688 5	74.0633	8.1 0	8.0 0	8.0 0	8.0 0	8.1 5	8.2 0
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.688 3	74.0633	8.0 5	7.9 0	7.8 5	7.8 0	8.2 0	7.6 5
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.242 4	76.3707	8.0 5	8.5 0	7.7 5	8.2 0	7.9 4	7.9 0

10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213	7.60	7.95	8.05	8.05	8.29	7.55
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797	7.65	7.80	7.95	8.15	8.21	7.65
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627	8.15	8.35	8.15	8.25	7.93	8.35
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566	8.15	8.25	8.15	8.15	7.85	8.45
14	2781	Krishna at D/S aof Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999	7.90	8.40	7.75	8.15	8.15	7.90
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789	7.75	8.05	8.32	8.00	8.00	7.85
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Monthly	16.0019	78.365	7.55	7.25	7.35	7.55	7.50	7.55
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.3388	77.6102	7.90	8.00	7.70	7.60	8.09	7.85
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.6947	79.6899	8.20	7.15	7.38	7.25	8.12	7.90
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.8019	80.1296	7.90	7.65	7.80	7.70	7.61	7.70
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.5826	80.3435	8.00	7.60	7.90	7.70	7.70	7.70
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.4925	80.6408	7.85	7.55	7.80	7.70	7.75	7.65
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.0879	78.8902	7.75	7.45	7.20	7.60	7.50	7.45
23	1782	Krishna at Hamsaladevi Puligadda aqueduct near Avanigadda(V), Krishna District	Andhra Pradesh	Monthly	16.0001	81.0791	7.65	7.50	7.65	7.60	7.70	7.90

Table 4S. The average annual Electrical Conductivity ( $\mu\text{mho/cm}$ ) along the Krishna River at different monitoring stations (2018-2023)

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1153	Krishna River at Rajapur Weir, Village- Rajapur, Taluka- Shirol, District- Kolhapur.	Maharashtra	Monthly	16.6301	74.6639	478	555	523	491	460	587
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.2953	74.1888	221	358	343	329	315	1084

3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	447	566	1407	2249	3090	2308
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801	30202	459	458	457	642	2162
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903	444	1286	895	505	2012	446
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913	365	402	775	1148	366	1867
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633	445	393	455	517	401	481
8	2188	Krishna River at Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633	440	412	528	645	441	2423
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707	545	1845	700	1461	1146	830
10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213	760	634	575	520	546	585
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797	705	766	548	518	576	615
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627	1134	1235	1097	1011	927	1322
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566	845	638	757	978	846	1323
14	2781	Krishna at D/S of Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999	545	1876	618	1138	731	829
15	1784	Krishna at Thangadi, Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789	995	759	1011	1009	913	803
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Monthly	16.0019	78.365	935	539	819	859	907	1123
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.3388	77.6102	930	677	1098	1015	912	1068
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.6947	79.6899	1290	883	850	962	1011	1161
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.8019	80.1296	824	675	954	750	835	861
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.5826	80.3435	601	501	774	708	758	773
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.4925	80.6408	602	664	763	726	729	654
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.0879	78.8902	466	389	623	538	601	711
23	1782	Krishna at Hamsaladevi Puligadda aqueduct near Avaniigadda(V), Krishna District	Andhra Pradesh	Monthly	16.0001	81.0791	32010	29710	28040	24500	22700	17595

Table 5S. The average annual Biochemical Oxygen Demand (mg/L) along the Krishna River at different monitoring stations (2018-2023)

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
------	---------------	---------------	--------	-----------	----------	-----------	------	------	------	------	------	------

1	1153	Krishna River at Rajapur Weir, Village- Rajapur, Taluka- Shirol, District- Kolhapur.	Maharashtra	Monthly	16.6301	74.6639	2.50	2.30	2.0	1.7	1.9	2.4
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.2953	74.1888	5.50	4.90	4.9	4.9	5.0	4.0
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	2.40	2.30	2.1	2.0	1.9	2.9
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801	7.50	2.30	2.2	2.2	1.9	2.4
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903	2.50	2.10	1.8	1.6	1.8	2.4
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913	5.25	5.00	4.9	4.9	4.8	4.3
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633	4.60	5.50	4.9	4.3	4.6	3.9
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633	5.15	4.55	4.5	4.6	4.8	5.7
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707	4.50	2.25	1.7	1.8	2.2	2.6
10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213	1.20	2.30	1.7	1.9	1.7	2.2
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797	1.30	1.55	1.2	1.9	1.7	2.4
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627	2.80	5	33.2	2.5	2.5	4.5
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566	2.50	2.30	2.0	2.8	4.0	2.6
14	2781	Krishna at D/S aof Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999	4.00	2.45	2.0	1.9	2.0	2.9
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789	0	3.00	25.0	3.0	2.5	2.0
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Monthly	16.0019	78.365	1.80	1.60	0	1.8	2.0	1.9
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.3388	77.6102	4.00	1.70	2.6	2.5	2.1	2.4
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.6947	79.6899	0	2.50	16.5	2.6	2.7	2.5
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.8019	80.1296	1.50	1.30	1.8	2.5	2.6	2.6

20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.5826	80.3435	1.90	1.10	1.7	2.2	2.6	2.6
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.4925	80.6408	1.50	1.20	1.5	2.4	2.6	2.6
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.0879	78.8902	1.40	1.30	1.5	1.8	1.6	1.3
23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near Avanigadda(V), Krishna District	Andhra Pradesh	Monthly	16.0001	81.0791	4.40	2.20	2.4	2.6	2.7	2.7

Table 6S. The average annual Nitrate (mg/L) along the Krishna River at different monitoring stations (2018-2023)

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023	
1	1153	Krishna River at Rajapur Weir, Village- Rajapur, Taluka- Shirol, District- Kolhapur.	Maharashtra	Monthly	16.6301	74.6639	1.10	1.45	2.05	2.65	2.61	2.09	
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.2953	74.1888	1.60	2.55	2.29	2.03	1.77	1.02	
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	0.55	2.15	2.48	2.81	3.14	1.44	
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801	1.00	2.70	2.63	2.55	2.66	2.10	
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903	1.00	1.35	2.00	2.65	2.89	2.51	
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913	1.55	0.25	2.31	2.69	2.93	0.93	
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633	2.30	3.00	3.67	4.34	3.04	1.96	
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633	2.30	0.25	2.36	2.40	2.79	1.59	
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707	5.70	22.6	0	1.76	3.47	4.66	5.86
10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213	8.55	5.95	2.33	4.31	23.1	12.5	
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797	8.80	6.70	2.44	4.60	23.8	14.3	
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627	0.05	0.25	0.44	0.30	1.86	5.07	
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566	0.10	0.29	0.40	0.35	1.42	2.05	
14	2781	Krishna at D/S of Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999	5.75	23.4	0	1.37	3.93	2.68	9.61

15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789	8.15	1.00	5.22	2.50	5.23	3.15
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Monthly	16.0019	78.365	1.60	3.30	1.06	0.99	1.83	0.65
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.3388	77.6102	1.40	1.25	1.87	1.98	4.62	3.20
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.6947	79.6899	18.7	21.3				25.2
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.8019	80.1296	5	5	6.76	9.12	5.24	3
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.5826	80.3435	0.95	1.00	1.27	1.19	1.43	1.41
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.4925	80.6408	2.50	0.95	0.93	1.28	1.60	1.35
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.0879	78.8902	0.80	0.86	0.85	1.08	1.25	0.95
23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near AvaniGadda(V), Krishna District	Andhra Pradesh	Monthly	16.0001	81.0791	3.55	1.00	1.17	0.80	0.86	0.83
							1.70	0.90	0.84	1.46	1.38	1.05

Table 7S. The average annual Fecal Coliforms ((MPN/ 100 mL) along the Krishna River at different monitoring stations (2018-2023)

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1153	Krishna River at Rajapur Weir, Village- Rajapur, Taluka- Shirol, District- Kolhapur.	Maharashtra	Monthly	16.6301	74.6639	10.5	11.6	8.3	5.0	7.0	7.5
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.2953	74.1888	165.		128.			
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	10.5	8.3	7.5	6.8	6.0	8.0
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801	37.0	9.0	7.8	6.5	6.0	7.5
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903	13.0	7.0	6.8	6.5	7.0	8.0
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913	155.					
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633	142.		121.			
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633	222.		156.			
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707	560.		635.	730.		1060.
							0	985.0	0	0	895.0	0

10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.640 9	74.8213	505. 0	1010. 0	635. 0	930. 0	635.0	730.0
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.557 5	74.6797	505. 0	1150. 0	570. 0	730. 0	635.0	635.0
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.380 5	77.3627	620. 0	345.0	345. 0	330. 0	2065. 0	400.0
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.369 2	76.6566	555. 0	230.0	310. 0	397. 0	2335. 0	315.0
14	2781	Krishna at D/S aof Alamatti Dam,	Karnataka	Monthly	16.325 1	75.8999	485. 0	585.0	635. 0	730. 0	570.0	635.0
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.424 2	77.2789	61.0	1.8	2.0	14.5	4.0	2.0
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Monthly	16.001 9	78.365	2.0	100.9	81.5	0	218.0	202.5
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.338 8	77.6102	41.0	1.8	3.0	14.5	6.5	2.0
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.694 7	79.6899	63.5	1.8	0	5.5	7.5	8.5
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.801 9	80.1296	3.0	2.4	3.0	3.0	26.0	16.0
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.582 6	80.3435	2.0	2.4	3.0	3.0	16.5	23.0
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.492 5	80.6408	3.0	2.4	12.5	3.0	20.0	9.5
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.087 9	78.8902	51.0	150.9	186. 0	215. 0	259.5	247.5
23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near Avanigadda(V), Krishna District	Andhra Pradesh	Monthly	16.000 1	81.0791	3.0	3.0	3.0	2.5	24.5	7.5

Table 8S. The average annual Total Coliforms along the Krishna River at different monitoring stations (2018-2023).

S.No	Station codes	Station names	States	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1153	Krishna River at Rajapur Weir, Village-Rajapur, Taluka-Shirol, District-Kolhapur.	Maharashtra	Monthly	16.630 1	74.6639	101. 5	89.5	90.0	26.0	28.5	33.5
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Monthly	17.295 3	74.1888	1075. .0	1075. .0	658. 6	493. 3	202.5	195. 0
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Monthly	16.824	74.6495	85.5	80.0	183. 8	41.7	22.5	27.5

4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Monthly	17.0293	74.3801	278.5	92.0	62.8	26.5	23.0	34.0
5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Monthly	16.6814	74.5903	143.0	76.5	54.0	28.0	29.5	32.0
6	2190	Krishna River at Wai, Satara	Maharashtra	Monthly	17.9493	73.8913	1250.0	1175.0	685.0	477.5	185.0	167.5
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Monthly	17.6885	74.0633	1250.0	1350.0	1001.3	835.0	197.5	297.5
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Monthly	17.6883	74.0633	1250.0	1175.0	917.5	480.0	185.0	287.5
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Monthly	16.2424	76.3707	1250.0	1850.0	952.5	1260.0	1660.0	2060.0
10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Monthly	16.6409	74.8213	1050.0	2050.0	1250.0	1600.0	1260.0	1260.0
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Monthly	16.5575	74.6797	1050.0	2400.0	1250.0	1270.0	1600.0	1260.0
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Monthly	16.3805	77.3627	1850.0	1560.0	1550.0	1860.0	46250.0	1860.0
13	1028	Krishna at Tintini Bridge,	Karnataka	Monthly	16.3692	76.6566	1850.0	1070.0	1560.0	1670.0	17675.0	1810.0
14	2781	Krishna at D/S aof Alamatti Dam,	Karnataka	Monthly	16.3251	75.8999	870.0	1150.0	1260.0	1260.0	1260.0	1260.0
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Monthly	16.4242	77.2789	512.5	20.0	474.0	183.5	156.0	35.5
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Monthly	16.0019	78.365	450.0	800.0	451.0	600.0	693.0	797.5
17	39	Krishna at Gadwal Bridge	Telangana	Monthly	16.3388	77.6102	363.0	22.0	175.0	217.0	156.0	45.5
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Monthly	16.6947	79.6899	405.0	44.5	461.0	33.5	23.5	33.0
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Monthly	16.8019	80.1296	1050.0	710.0	196.5	135.0	340.0	267.0
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Monthly	16.5826	80.3435	950.0	475.0	157.5	121.5	229.5	267.5
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Monthly	16.4925	80.6408	950.0	505.0	147.0	112.5	262.0	267.0
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Monthly	16.0879	78.8902	900.0	900.0	737.5	910.0	925.0	700.0

23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near Avaniagadda(V), Krishna District	Andhra Pradesh	Monthly	16.0001	81.0791	1350.0	865.0	215.0	92.0	216.0	211.5
----	------	--	----------------	---------	---------	---------	--------	-------	-------	------	-------	-------

Table 9S. The monitoring station-wise average annual Temperature (°c) in the Krishna river tributaries during 2018-2023

S.no	Station codes	Station names	States	River	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	26.0	26.0	29.0	24.5	27	28.3
2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur, Pune	Maharashtra	Bhima	Monthly	18.6457	74.0564	29.0	29.0	28.0		27	27.5
3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	Monthly	18.5433	73.885	26.0	26.0	29.0	26.0	28	28.0
4	1191	Bhima at Pargaon (After Confl.with Mutha), Pargaon, Daund, Pune	Maharashtra	Bhima	Monthly	18.5603	74.3733	26.8	26.8	30.0	26.0	26	28.0
5	1192	Bhima after Confl. with Daund, Daund, Pune	Maharashtra	Bhima	Monthly	18.4646	74.5836	26.0	26.0	29.0	25.8	26	28.5
6	1188	Bhima at Narsingpur, (D/S Af.Confl.with R.Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	Monthly	17.9858	75.1162	27.0	27.0	35.0	31.5	32	32.5
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	Monthly	17.7037	75.5446	24.5	24.5	35.0	30.5	33	32.5
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Bhima	Monthly	17.1792	76.5666	28.0	28.0	28.0	29.0	29	28.0
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Bhima	Monthly	17.0693	76.7943	29.5	29.5	28.5	29.5	29	28.0
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	Monthly	16.7341	77.1307	31.0	31.0	32.0	29.0	31	30.0
11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Bhima	Monthly	17.0435	76.8145	29.0	29.0	31.0	29.5	29	28.0
12	2656	Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Bhima	Monthly	18.2021	75.089	25.8	25.8	29.0	26.3	25	28.5
13	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	Monthly	14.3254	75.7711	19	27.5	28.5	27.5	28.6	28.5
14	29	Tungabhadra at Ullanur	Karnataka	Tungabhadra	Monthly	15.4948	76.6924	24	26.0	27.5	28.0	29.5	23.0
15	38	Tungabhadra at Honnali Bridge	Karnataka	Tungabhadra	Monthly	14.2361	75.6594	27	26.5	26.5	27.0	27.0	27.5

16	2767	Tungabhadra at U/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	18	26.0	27.0	26.0	27.1	27.0
17	2768	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	18	27.0	28.5	27.0	28.2	28.0
18	2769	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	Monthly	14.5265	75.7961	18	27.0	28.0	27.5	28.2	28.5
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	Monthly	14.5158	75.7979	18	26.0	27.5	26.0	27.1	28.0
20	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	Monthly	15.4123	76.5863	24	29.0	27.0	28.0	31.5	26.0
21	2766	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	18	26.0	27.0	26.0	27.6	27.0
22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.8483	78.0349	26	22.0	24.0	24.0	25.5	25.0
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.9445	77.4197	26	21.5	25.5	23.5	25.5	25.0
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7462	74.4457	24.0	25.5	33.0	31.5	26.5	26.0
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7215	74.5948	25.5	25.0	32.0	29.5	26.5	26.0
26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6885	74.1695	25.0	23.5	31.0	30.0	26.0	26.0
27	1905	Panchaganga D/S of Kolhapur Town, Uchegaon, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6955	74.275	26.0	25.0	30.0	30.5	26.5	26.0
28	1187	Malprabha at D/S of Khanapur Village,	Karnataka	Malprabha	Monthly	15.6334	74.5103	26.5	28.0	25.0	25.5	26.0	26.0
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnataka	Malprabha	Monthly	15.798	75.1915	26.5	29.0	29.0	25.5	25.0	28.0
30	1186	Malprabha at D/S of Aihole Town,	Karnataka	Malprabha	Monthly	16.0093	75.878	27.0	23.0	18.5	19.0	22.5	20.0
31	2764	Malprabha at Badami Bridge,	Karnataka	Malprabha	Monthly	15.8757	75.7223	26.5	23.0	19.0	18.5	21.5	20.0
32	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Bhadra	Monthly	13.8323	75.7132	23.5	26.5	29.0	28.5	26.5	27.0
33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Bhadra	Monthly	13.9893	75.6837	23.0	27.0	28.0	28.0	26.5	27.0
34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	24.0	27.0	28.5	28.5	25.5	27.0
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	24.0	19.0	21.0	24.5	24.5	23.0
36	4253	Musi sample at bapughat sangam u/s of Musi River Musi at	Telangana	Musi	Monthly	17.3718	78.4124	28.9	29.4	28.7	28.6	28.1	28.4
37	4656	Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	29	29.5	28.8	28.7	28.2	28.5
38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	29.1	29.6	28.9	28.8	28.3	28.6

39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	29.2	29.7	29	28.9	28.4	28.7
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	29.1	29.6	28.9	28.8	28.3	28.6
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	29	29.5	28.8	28.7	28.2	28.5
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	28.8	29.3	28.5	28.4	27.9	28.1
43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	28.6	29.1	28.3	28.2	27.7	27.9
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	28.4	28.9	28.1	28	27.5	27.7
45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Monthly	17.2476	79.492	28.3	28.8	28	27.9	27.4	27.6

Table 10S. The monitoring station-wise average annual pH in the Krishna river tributaries during 2018-2023.

S.no	Station code	Station names	States	River	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023	
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	7.5	7.5	7.5	7.7	8.0	7.5	
2	2655	Bhima River at Koregaon Near Shirur, Pune	Maharashtra	Bhima	Monthly	18.6457	74.0564	7.8	5	8.1	7.9	8.0	8.0	7.9
3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	Monthly	18.5433	73.885	7.3	5	7.6	7.5	7.6	7.8	7.4
4	1191	Bhima at Pargaon (After Confl. with Mutha), Pargaon, Daund, Pune	Maharashtra	Bhima	Monthly	18.5603	74.3733	7.7	8.1	7.7	7.8	7.9	7.7	
5	1192	Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Bhima	Monthly	18.4646	74.5836	7.8	8.1	7.7	7.9	7.9	7.8	
6	1188	Bhima at Narsingpur, (D/S Af. Confl. with R. Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	Monthly	17.9858	75.1162	8.2	8.0	8.1	8.2	8.4	8.2	
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	Monthly	17.7037	75.5446	8.1	8.1	7.8	8.0	8.3	8.1	
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Bhima	Monthly	17.1792	76.5666	7.9	5	8.1	8.0	7.7	8.0	8.0
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Bhima	Monthly	17.0693	76.7943	8.2	5	8.5	8.3	8.2	7.8	8.3
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	Monthly	16.7341	77.1307	8.3	8.4	7.9	8.0	8.4	8.3	

11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Bhima	Monthly	17.0435	76.8145	8.15	8.3	8.1	8.3	8.0	8.2
12	2656	Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Bhima	Monthly	18.2021	75.089	7.85	8.0	7.8	8.0	8.2	7.9
13	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	Monthly	14.3254	75.7711	7.9	7.6	7.6	8.0	7.8	8.0
14	29	Tungabhadra at Ullanur	Karnataka	Tungabhadra	Monthly	15.4948	76.6924	7.8	8.3	8.3	8.2	8.2	7.5
15	38	Tungabhadra at Honnali Bridge	Karnataka	Tungabhadra	Monthly	14.2361	75.6594	7.9	7.7	7.7	7.8	7.8	8.0
16	2767	Tungabhadra at U/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	7.8	7.6	7.6	8.0	7.6	7.8
17	2768	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	7.6	7.5	7.5	7.9	7.6	7.6
18	2769	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	Monthly	14.5265	75.7961	7.9	7.6	7.6	7.8	7.7	7.8
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	Monthly	14.5158	75.7979	7.7	7.3	7.3	7.7	7.4	7.7
20	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	Monthly	15.4123	76.5863	7.8	8.4	8.4	8.1	8.2	7.9
21	2766	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	7.8	7.6	7.6	8.0	7.6	7.8
22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.8483	78.0349	7.2	7.5	7.5	7.6	7.4	7.7
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.9445	77.4197	7.9	7.1	7.1	7.4	7.6	7.7
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7462	74.4457	7.5	7.7	7.6	7.5	7.6	8.0
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7215	74.5948	7.7	7.6	7.6	7.5	7.6	8.1
26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6885	74.1695	7.3	7.4	7.4	7.4	7.7	7.8
27	1905	Panchaganga D/S of Kolhapur Town, Uchegaon, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6955	74.275	7.1	7.5	7.5	7.4	7.5	8.0
28	1187	Malprabha at D/S of Khanapur Village,	Karnataka	Malprabha	Monthly	15.6334	74.5103	7.4	7.8	7.8	7.8	8.1	7.7
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnataka	Malprabha	Monthly	15.798	75.1915	7.7	7.9	8.2	7.7	8.3	8.2
30	1186	Malprabha at D/S of Aihole Town,	Karnataka	Malprabha	Monthly	16.0093	75.878	7.6	7.9	8.1	8.4	8.2	8.4
31	2764	Malprabha at Badami Bridge,	Karnataka	Malprabha	Monthly	15.8757	75.7223	7.6	8.1	8.1	8.1	8.2	8.2
32	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Bhadra	Monthly	13.8323	75.7132	7.8	7.6	7.7	7.6	7.4	7.8

33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Bhadra	Monthly	13.9893	75.6837	7.6	7.6	7.8	7.8	7.6	7.5
34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	7.6	7.6	7.7	7.7	7.6	7.6
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	7.2	7.0	7.0	6.8	7.3	7.6
36	4253	Musi sample at bapughat sangamu/s of Musi	Telangana	Musi	Monthly	17.3718	78.4124	7.3	7.3	7.3	7.6	7.4	7.3
37	4656	River Musi at Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	7.2	7.4	7.4	7.5	7.4	7.2
38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	9	7.4	7.3	7.4	7.5	7.5
39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	7.4	7.3	7.5	7.5	7.6	7.3
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	7.3	7.3	7.4	7.4	7.4	7.2
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	7	7.4	7.4	7.3	7.4	7.4
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	8.0	7.4	7.3	7.5	7.4	7.2
43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	1	7.7	7.0	7.2	7.0	7.5
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	8.0	7.2	7.2	7.0	7.6	7.2
45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Monthly	17.2476	79.492	8.4	7.3	7.3	7.3	7.8	7.8

Table 11S. The monitoring station-wise average annual electrical conductivity ( $\mu\text{mho/cm}$ ) in the Krishna river tributaries during 2018-2023.

S. no	Station codes	Station names	States	River	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	598.0	144.75	418.5	372.0	705.5	596.0
2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur, Pune	Maharashtra	Bhima	Monthly	18.6457	74.0564	644.5	562.5	774.6	108.9	758.5	468.0
3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	Monthly	18.5433	73.885	509.5	470.0	498.7	571.5	562.5	511.0

4	1191	Bhima at Pargaon (After Confl.with Mula Mutha),Pargaon , Daund, Pune	Maharashtra	Bhima	Monthly	18.5603	74.3733	664.0	809.5	687.5	612.0	472.2.5	975.0
5	1192	Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Bhima	Monthly	18.4646	74.5836	657.0	852.5	845.0	951.5	106.3.5	985.0
6	1188	Bhima at Narsingpur, (D/S Af.Confl.with R.Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	Monthly	17.9858	75.1162	740.0	825.5	102.5.0	504.2.5	527.7.0	369.3.0
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	Monthly	17.7037	75.5446	100.5.5	616.6	111.7.5	137.1.0	137.1.5	166.6.5
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Bhima	Monthly	17.1792	76.5666	814.0	660.0	122.1.0	142.0.5	150.6.0	153.0.0
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Bhima	Monthly	17.0693	76.7943	805.5	702.5	109.7.0	127.4.0	146.3.5	108.7.5
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	Monthly	16.7341	77.1307	763.0	947.0	858.0	858.0	110.6.5	931.5
11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Bhima	Monthly	17.0435	76.8145	791.0	708.0	103.3.5	119.6.0	103.0.5	104.8.0
12	2656	Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Bhima	Monthly	18.2021	75.089	547.0	885.0	777.5	768.0	987.5	649.5
13	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	Monthly	14.3254	75.7711	266.0	307.5	307.5	380.0	419.5	436.5
14	29	Tungabhadra at Ullanur	Karnataka	Tungabhadra	Monthly	15.4948	76.6924	241.5	600.0	600.0	767.5	578.5	124.9.5
15	38	Tungabhadra at Honnali Bridge	Karnataka	Tungabhadra	Monthly	14.2361	75.6594	196.0	335.0	335.0	329.0	389.0	221.0
16	2767	Tungabhadra at U/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	307.0	259.0	259.0	349.0	326.0	228.0
17	2768	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	142.2.0	590.0	590.0	470.0	740.0	107.5.0
18	2769	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	Monthly	14.5265	75.7961	685.0	245.0	245.0	380.0	392.0	766.5
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	Monthly	14.5158	75.7979	330.0	375.5	375.5	396.0	404.0	369.0

20	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	Monthly	15.4123	76.5863	395.0	375.5	375.5	470.0	464.0	614.0
21	2766	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	276.0	275.0	275.0	329.5	347.5	236.0
22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.8483	78.0349	112.5	912.0	912.0	122.65	942.5	152.9
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.9445	77.4197	108.25	832.0	832.0	803.0	113.3	130.8
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7462	74.4457	267.5	346.5	356.5	254.0	454.0	409.0
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7215	74.5948	471.0	507.5	429.5	427.0	636.5	592.0
26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6885	74.1695	457.5	121.9	225.0	165.5	187.45	138.5
27	1905	Panchaganga D/S of Kolhapur Town, Uchegaon, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6955	74.275	617.5	250.5	301.0	254.5	599.5	153.0
28	1187	Malprabha at D/S of Khanapur Village,	Karnataka	Malprabha	Monthly	15.6334	74.5103	300.0	194.0	197.0	319.0	266.0	229.0
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnataka	Malprabha	Monthly	15.798	75.1915	490.0	616.5	261.0	299.0	370.0	393.0
30	1186	Malprabha at D/S of Aihole Town,	Karnataka	Malprabha	Monthly	16.0093	75.878	925.0	460.5	755.0	984.0	853.0	125.3
31	2764	Malprabha at Badami Bridge,	Karnataka	Malprabha	Monthly	15.8757	75.7223	933.0	575.5	694.0	982.0	916.5	128.8
32	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Bhadra	Monthly	13.8323	75.7132	235.0	225.0	250.0	250.0	241.0	175.0
33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Bhadra	Monthly	13.9893	75.6837	203.0	190.0	231.0	240.5	228.5	161.0
34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	195.0	202.5	182.5	220.0	190.0	176.5
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	89.5	85.0	83.0	83.0	99.5	105.5
36	4253	Musi sample at bapughat sangam u/s of Musi	Telangana	Musi	Monthly	17.3718	78.4124	136.7	144.6	137.8	139.0	125.9	117.8
37	4656	River Musi at Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	160.9	128.0	123.2	127.5	116.9	125.0

38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	1454	1347	1292	1339	1158	1380
39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	1395.0	1435	1565	1632	1609	1478
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	1617.0	1355	1334	1332	1223	1310
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	1410	1356	1291	1327	1199	1316
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	1459.0	1370	1292	1359	1239	1328
43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	1559	1514	1505	1523	1453	1505
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	1510.0	1490	1269	1523	1454	1513
45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Monthly	17.2476	79.492	1634	1844	1099	1278	1355	1420

Table 12S. The monitoring station-wise average annual Dissolved Oxygen (DO) concentration (mg/L) in the Krishna river tributaries during 2018-2023.

S.no	Station code	Station names	States	River	Freq uency	Lat itude	Lon gitu de	2018	2019	2020	2021	2022	2023
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	3.5	4.3	4.4	5.2	5.5	3.5
2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur, Pune	Maharashtra	Bhima	Monthly	18.6457	74.0564	5.6	3.9	5.9	5.7	5.4	5.6
3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	Monthly	18.5433	73.885	3.9	3.5	5.4	5.1	4.4	3.9
4	1191	Bhima at Pargaon (After Confl. with Mula Mutha), Pargaon, Daund, Pune	Maharashtra	Bhima	Monthly	18.5603	74.3733	5.2	5.2	5.2	5.6	5.1	5.0
5	1192	Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Bhima	Monthly	18.4646	74.5836	5.1	4.9	5.0	5.6	5.1	5.2
6	1188	Bhima at Narsingpur, (D/S Af. Confl. with R. Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	Monthly	17.9858	75.1162	5.8	4.1	6.0	5.7	5.5	5.9
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	Monthly	17.7037	75.5446	5.3	4.8	6.0	6.0	5.3	5.4

8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Bhima	Monthly	17.1792	76.5666	7.3	6.6	7.1	7.4	7.5	7.3
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Bhima	Monthly	17.0693	76.7943	9.05	7.1	7.1	7.2	7.4	9.1
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	Monthly	16.7341	77.1307	7.5	7.0	7.2	7.1	6.9	7.5
11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Bhima	Monthly	17.0435	76.8145	8.8	6.8	7.3	7.4	7.6	8.8
12	2656	Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Bhima	Monthly	18.2021	75.089	5.5	5.7	6.2	1.3	5.5	5.6
13	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	Monthly	14.3254	75.7711	7.2	6.6	6.6	6.9	7.7	7.3
14	29	Tungabhadra at Ullanur	Karnataka	Tungabhadra	Monthly	15.4948	76.6924	7.3	7.3	7.3	7.3	5.4	4.1
15	38	Tungabhadra at Honnali Bridge	Karnataka	Tungabhadra	Monthly	14.2361	75.6594	7.2	7.2	7.2	7.1	7.2	7.3
16	2767	Tungabhadra at U/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	7.3	7.2	7.2	7.0	7.4	7.2
17	2768	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	5.8	5.9	5.9	5.8	5.5	6.5
18	2769	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	Monthly	14.5265	75.7961	5.8	6.3	6.3	6.0	6.2	6.5
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	Monthly	14.5158	75.7979	6.3	6.8	6.8	6.3	6.1	6.9
20	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	Monthly	15.4123	76.5863	7.3	7.2	7.2	7.5	6.0	7.5
21	2766	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	7.3	7.0	7.0	7.2	7.1	7.2
22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.8483	78.0349	6.2	6.3	6.3	6.7	5.7	5.8
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.9445	77.4197	6.5	6.1	6.1	6.6	5.5	5.9
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kohlapur	Maharashtra	Panchaganga	Monthly	16.7462	74.4457	6.5	6.6	6.4	6.5	5.9	6.7
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7215	74.5948	6.6	6.5	6.6	6.6	6.2	6.6

26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6885	74.1695	5.0	6.4	6.8	6.7	6.5	6.6
27	1905	Panchaganga D/S of Kolhapur Town, Ucheagaon, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6955	74.275	5.1	6.5	6.8	6.5	6.1	6.6
28	1187	Malprabha at D/S of Khanapur Village,	Karnataka	Malprabha	Monthly	15.6334	74.5103	7.0	6.7	8.2	7.6	6.5	7.0
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnataka	Malprabha	Monthly	15.798	75.1915	7.5	9.0	5.0	7.4	6.8	7.2
30	1186	Malprabha at D/S of Aihole Town,	Karnataka	Malprabha	Monthly	16.0093	75.878	7.4	6.5	6.7	6.6	7.8	8.4
31	2764	Malprabha at Badami Bridge,	Karnataka	Malprabha	Monthly	15.8757	75.7223	7.0	6.5	6.8	6.4	8.1	8.3
32	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Bhadra	Monthly	13.8323	75.7132	7.0	6.8	6.6	5.6	7.2	6.5
33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Bhadra	Monthly	13.9893	75.6837	6.9	7.2	6.5	6.4	7.1	6.9
34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	7.4	7.0	6.5	6.4	6.6	7.4
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	6.1	6.3	7.0	7.1	7.2	7.3
36	4253	Musi sample at bapughat sangam u/s of Musi	Telangana	Musi	Monthly	17.3718	78.4124	1.6	0.1	0.3	0.7	0.0	0.7
37	4656	River Musi at Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	1.5	1.4	0.1	0.5	0.7	0.4
38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	0.1	0.1	0.2	0.3	0.7	0.3
39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	3.0	3.2	0.2	0.3	0.3	0.3
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	5.0	1.1	0.4	0.4	0.6	0.3
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	1.0	0.8	1.0	0.7	1.0	0.5
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	1.0	3.4	2.0	1.6	1.8	1.5
43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	5.7	6.5	5.6	5.6	5.7	6.3
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	5.0	6.8	5.6	5.6	6.0	6.4

45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Mon thly	17. 247 6	79.4 92	6. 5	6. 2	5. 8	6. 0	6. 3	6. 8
----	------	---	-----------	------	-------------	-----------------	------------	---------	---------	---------	---------	---------	---------

Table 13S. The monitoring station-wise average annual biochemical oxygen demand (mg/L) in the Krishna river tributaries during 2018-2023.

S.no	Station codes	Station names	States	River	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	22.5	2.4	1.1	7.3	5.2	2.5
2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur, Pune	Maharashtra	Bhima	Monthly	18.6457	74.0564	4.2	8.9	6.0	4.5	5.3	4.2
3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	Monthly	18.5433	73.885	16.7	1.4	1.3	8.8	1.7	1.7
4	1191	Bhima at Pargaon (After Confl. with Mula Mutha), Pargaon, Daund, Pune	Maharashtra	Bhima	Monthly	18.5603	74.3733	7.45	5.3	8.5	5.2	7.4	7.5
5	1192	Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Bhima	Monthly	18.4646	74.5836	5.95	4.9	6.9	5.4	7.4	6.0
6	1188	Bhima at Narsingpur, (D/S Af. Confl. with R. Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	Monthly	17.9858	75.1162	5.4	6.9	7.6	5.8	8.6	5.4
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	Monthly	17.7037	75.5446	6.45	5.2	6.5	5.1	5.6	6.5
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Bhima	Monthly	17.1792	76.5666	5.5	3.0	2.5	3.0	1.1	5.5
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Bhima	Monthly	17.0693	76.7943	3.3	3.0	2.8	2.9	5.0	3.0
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	Monthly	16.7341	77.1307	2.5	3.3	2.8	2.5	2.5	2.5
11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Bhima	Monthly	17.0435	76.8145	2.65	3.3	2.8	2.5	3.0	2.7
12	2656	Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Bhima	Monthly	18.2021	75.089	5.15	5.2	5.7	5.0	6.4	5.2
13	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	Monthly	14.3254	75.7711	2.7	2.5	2.5	2.6	2.8	2.2
14	29	Tungabhadra at Ullanur	Karnataka	Tungabhadra	Monthly	15.4948	76.6924	1.9	3.0	3.0	2.5	8.5	4.4

15	38	Tungabhadra at Honnali Bridge	Karnat aka	Tung abha dra	Mon thly	14. 236 1	75.6 594	2. 7	2. 8	2. 8	3. 4	2. 6	1. 9
16	2767	Tungabhadra at U/S of Hpf,	Karnat aka	Tung abha dra	Mon thly	14. 514 3	75.7 857	2. 8	2. 5	2. 5	2. 6	2. 5	2. 1
17	2768	Tungabhadra at D/S of Hpf,	Karnat aka	Tung abha dra	Mon thly	14. 514 3	75.7 857	9. 5	4. 6	4. 6	4. 2	5. 5	4. 7
18	2769	Tungabhadra at Jackwell Point,	Karnat aka	Tung abha dra	Mon thly	14. 526 5	75.7 961	3. 3	2. 5	2. 5	3. 1	2. 7	3. 4
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnat aka	Tung abha dra	Mon thly	14. 515 8	75.7 979	3. 9	3. 9	3. 9	3. 8	3. 7	4. 2
20	2776	Tungabhadra at D/S of Gangawathi,	Karnat aka	Tung abha dra	Mon thly	15. 412 3	76.5 863	2. 5	2. 5	2. 5	2. 5	1. 0	2. 5
21	2766	Tungabhadra at New Bridge,	Karnat aka	Tung abha dra	Mon thly	14. 514 3	75.7 857	2. 7	2. 5	2. 5	2. 5	2. 2	2. 1
22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhr a Prades h	Tung abha dra	Mon thly	15. 848 3	78.0 349	2. 3	1. 9	1. 9	2. 1	2. 6	2. 1
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhr a Prades h	Tung abha dra	Mon thly	15. 944 5	77.4 197	2. 2	1. 8	1. 8	2. 2	2. 8	1. 9
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Mahar ashtra	Panc haga nga	Mon thly	16. 746 2	74.4 457	2. 2	2. 3	2. 0	1. 9	2. 2	2. 8
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Mahar ashtra	Panc haga nga	Mon thly	16. 721 5	74.5 948	2. 3	2. 1	1. 8	1. 9	1. 9	2. 4
26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Mahar ashtra	Panc haga nga	Mon thly	16. 688 5	74.1 695	10. .5	2. 2	1. 8	1. 6	2. 0	2. 4
27	1905	Panchaganga D/S of Kolhapur Town, Uchegaon, Kolhapur	Mahar ashtra	Panc haga nga	Mon thly	16. 695 5	74.2 75	11. .0	2. 2	1. 9	2. 0	2. 1	2. 4
28	1187	Malprabha at D/S of Khanapur Village,	Karnat aka	Malp rabha	Mon thly	15. 633 4	74.5 103	2. 3	2. 0	2. 9	2. 0	2. 0	2. 1
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnat aka	Malp rabha	Mon thly	15. 798	75.1 915	3. 0	1. 5	1. 5	1. 6	1. 5	2. 1
30	1186	Malprabha at D/S of Aihole Town,	Karnat aka	Malp rabha	Mon thly	16. 009 3	75.8 78	2. 5	1. 7	2. 8	2. 0	2. 3	2. 8
31	2764	Malprabha at Badami Bridge,	Karnat aka	Malp rabha	Mon thly	15. 875 7	75.7 223	2. 0	1. 5	2. 8	2. 0	2. 3	2. 4
32	1387	Bhadra at D/S of Bhadravathi,	Karnat aka	Bhad ra	Mon thly	13. 832 3	75.7 132	4. 1	3. 6	3. 3	4. 9	2. 6	2. 2
33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnat aka	Bhad ra	Mon thly	13. 989 3	75.6 837	3. 3	2. 8	2. 7	2. 8	2. 2	2. 0

34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	2.5	2.4	2.5	2.3	2.0	1.7
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	1.4	1.5	1.7	1.3	1.5	1.6
36	4253	Musi sample at bapughat sangam u/s of Musi	Telangana	Musi	Monthly	17.3718	78.4124	21	28	19	8.1	7.9	7.7
37	4656	River Musi at Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	14.0	4.0	2.2	1.9	1.1	0.3
38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	33	30	17	0.7	0.6	0.4
39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	12.0	2.8	17.4	9.9	2.6	0.7
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	16.0	2.8	2.3	1.9	1.3	0.4
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	21	24	9.8	7.4	6.4	0.0
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	20.0	2.7	14.0	5.9	5.3	5.3
43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	4	3.2	4.4	5.5	5.0	3.3
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	17.0	3.7	4.5	5.5	5.0	3.5
45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Monthly	17.2476	79.492	5	3.6	4.3	4.2	4.0	3.8

Table 14S. The monitoring station-wise average annual nitrate levels (mg/L) in the Krishna river tributaries during 2018-2023.

S.no	Station codes	Station names	States	River	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	2.6	2.7	2.6	2.6	3.1	2.6
2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur,Pune	Maharashtra	Bhima	Monthly	18.6457	74.0564	2.85	4.4	4.5	4.5	3.4	2.9

3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	Monthly	18.5433	73.885	1.725	3.8	5.1	5.1	4.9	1.7
4	1191	Bhima at Pargaon (After Confl.with Mula Mutha),Pargaon, Daund, Pune	Maharashtra	Bhima	Monthly	18.5603	74.3733	5.71	3.7	4.8	4.8	4.5	5.7
5	1192	Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Bhima	Monthly	18.4646	74.5836	5.54	3.2	2.5	4.8	4.8	5.5
6	1188	Bhima at Narsingpur, (D/S Af.Confl.with R.Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	Monthly	17.9858	75.1162	1.535	2.9	2.6	2.5	2.8	1.5
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	Monthly	17.7037	75.5446	1.265	2.1	3.3	2.6	2.6	1.3
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Bhima	Monthly	17.1792	76.5666	1.995	0.4	1.2	0.7	6.0	2.0
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Bhima	Monthly	17.0693	76.7943	33.755	0.3	0.8	1.2	5.8	33.8
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	Monthly	16.7341	77.1307	5.955	0.3	1.0	0.6	0.4	6.0
11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Bhima	Monthly	17.0435	76.8145	3.68	0.3	4.8	1.0	2.9	3.7
12	2656	Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Bhima	Monthly	18.2021	75.089	2.695	3.2	5.2	5.2	2.7	2.7
13	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	Monthly	14.3254	75.7711	0.3	0.7	0.7	0.4	5.6	0.8
14	29	Tungabhadra at Ullanur	Karnataka	Tungabhadra	Monthly	15.4948	76.6924	0.2	0.3	0.3	0.4	7.6	4.2
15	38	Tungabhadra at Honnali Bridge	Karnataka	Tungabhadra	Monthly	14.2361	75.6594	0.5	0.3	0.3	0.3	2.1	0.8
16	2767	Tungabhadra at U/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	0.5	0.6	0.6	0.6	2.6	0.9
17	2768	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	0.6	0.6	0.6	0.8	2.8	1.5
18	2769	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	Monthly	14.5265	75.7961	0.4	0.7	0.7	0.4	2.7	0.9
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	Monthly	14.5158	75.7979	0.7	0.7	0.7	0.8	2.8	1.0
20	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	Monthly	15.4123	76.5863	0.2	0.3	0.3	0.3	10.5	1.8
21	2766	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	0.4	0.4	0.4	0.6	2.6	0.9

22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.8483	78.0349	2.2	1.3	1.3	10.4	1.1	1.4
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.9445	77.4197	2.0	1.3	1.3	1.2	0.9	1.0
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7462	74.4457	1.6	2.2	2.2	2.0	3.6	2.1
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7215	74.5948	1.5	1.2	1.2	2.0	4.4	2.0
26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6885	74.1695	1.3	1.2	1.2	2.2	1.6	1.5
27	1905	Panchaganga D/S of Kolhapur Town, Uchegaon, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6955	74.275	1.1	1.2	1.2	2.0	1.6	1.4
28	1187	Malprabha at D/S of Khanapur Village,	Karnataka	Malprabha	Monthly	15.6334	74.5103	2.3	4.2	1.3	6.3	11.8	8.5
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnataka	Malprabha	Monthly	15.798	75.1915	3.0	4.6	2.6	7.3	9.4	12.1
30	1186	Malprabha at D/S of Aihole Town,	Karnataka	Malprabha	Monthly	16.0093	75.878	7.5	7.8	2.3	4.7	19.5	20.9
31	2764	Malprabha at Badami Bridge,	Karnataka	Malprabha	Monthly	15.8757	75.7223	4.2	7.3	3.9	4.3	19.5	21.4
32	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Bhadra	Monthly	13.8323	75.7132	0.6	0.6	0.4	0.7	2.9	0.9
33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Bhadra	Monthly	13.9893	75.6837	0.5	0.5	0.5	0.7	3.1	0.8
34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	0.6	0.5	0.3	0.7	3.9	0.6
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	0.1	0.1	0.1	0.3	5.6	0.4
36	4253	Musi sample at bapughat sangam u/s of Musi River Musi at	Telangana	Musi	Monthly	17.3718	78.4124	7	17	9.5	6	4	4.8
37	4656	Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	8.0	19	6.6	11	6	5.7
38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	9	18	7.5	9	6	6.0
39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	17.0	6	5.8	8	6	7.0
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	12.0	19	7.4	8	6	6.0
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	11	18	7.3	8	6	6.5
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	18.0	35	10.2	8	5	6.5

43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	19	16	13.4	12	9	30.1
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	10.0	16	10.8	12	10	29.8
45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Monthly	17.2476	79.492	18	16	7.8	9	7	25.3

Table 15S. The monitoring station-wise average annual faecal coliform levels (MPN/ 100 mL) in the Krishna river tributaries during 2018-2023.

S. no	Station codes	Station names	States	River	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	124	904	300	123	17	118
2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur, Pune	Maharashtra	Bhima	Monthly	18.6457	74.0564	135	310	179	31	17	27
3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	Monthly	18.5433	73.885	925	855	925	285	25	138
4	1191	Bhima at Pargaon (After Confl. with Mula Mutha), Pargaon, Daund, Pune	Maharashtra	Bhima	Monthly	18.5603	74.3733	72	281	62	19	14	104
5	1192	Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Bhima	Monthly	18.4646	74.5836	113	277	76	27	13	63
6	1188	Bhima at Narsingpur, (D/S Af. Confl. with R. Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	Monthly	17.9858	75.1162	153	188	10	22	21	64
7	28	Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	Monthly	17.7037	75.5446	87	105	42	23	19	26
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnataka	Bhima	Monthly	17.1792	76.5666	130	545	780	645	437	1301
9	1184	Bhima at Ferozabad Village (D/S),	Karnataka	Bhima	Monthly	17.0693	76.7943	750	305	460	920	230	1157
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	Monthly	16.7341	77.1307	144	500	635	375	535	262
11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnataka	Bhima	Monthly	17.0435	76.8145	980	470	765	875	246	360
12	2656	Bhima River-Backwater of	Maharashtra	Bhima	Monthly	18.2021	75.089	89	904	21	13	17	46

		Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune											
13	1029	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	Monthly	14.3254	75.7711	950	800	800	230	136	114
14	29	Tungabhadra at Ullanur	Karnataka	Tungabhadra	Monthly	15.4948	76.6924	461	249	249	435	471	2424
15	38	Tungabhadra at Honnali Bridge	Karnataka	Tungabhadra	Monthly	14.2361	75.6594	1200	400	400	362	82	94
16	2767	Tungabhadra at U/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	1100	950	950	335	166	71
17	2768	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	1100	900	900	440	180	53
18	2769	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	Monthly	14.5265	75.7961	1100	950	950	352	101	107
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	Monthly	14.5158	75.7979	25450	11450	11450	469	1112	2700
20	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	Monthly	15.4123	76.5863	309	205	205	362	590	385
21	2766	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	810	800	800	454	177	102
22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.8483	78.0349	51	51	51	276	286	328
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.9445	77.4197	51	150	150	282	352	389
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7462	74.4457	10	11	11	5	8	8
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7215	74.5948	11	12	9	7	8	7
26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6885	74.1695	58	12	8	6	8	9
27	1905	Panchaganga D/S of Kolhapur Town, Uchegaon, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6955	74.275	43	17	13	7	8	9
28	1187	Malprabha at D/S of Khanapur Village,	Karnataka	Malprabha	Monthly	15.6334	74.5103	25250	913	700	730	730	635
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnataka	Malprabha	Monthly	15.798	75.1915	520	985	560	730	675	600

30	1186	Malprabha at D/S of Aihole Town,	Karnataka	Malprabha	Monthly	16.0093	75.878	520	508	1010	730	1095	635
31	2764	Malprabha at Badami Bridge,	Karnataka	Malprabha	Monthly	15.8757	75.7223	560	610	1150	730	1135	730
32	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Bhadra	Monthly	13.8323	75.7132	26200	27500	8750	2471	610	234
33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Bhadra	Monthly	13.9893	75.6837	15650	7700	1750	2864	424	142
34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	695	700	700	3580	163	53
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	32	28	30	27	23	26
36	4253	Musi sample at bapughat sangam u/s of Musi	Telangana	Musi	Monthly	17.3718	78.4124	90	137.4	231	95	19	48.0
37	4656	River Musi at Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	30.0	452.5	338	112	25	25.5
38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	421	177.3	399	144	29	24.8
39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	421.0	266.7	121	84	23	26.0
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	94.0	510.0	227	111	29	26.4
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	192	209.4	159	99	29	30.5
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	337.0	214.8	158	87	26	22.9
43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	11	2.3	20	7	8	7.8
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	262.0	2.0	20	7	9	8.9
45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Monthly	17.2476	79.492	23	2.6	5	5	7	7.8

Table 16S. The monitoring station-wise average annual total coliforms levels (MPN/ 100 mL) in the Krishna river tributaries during 2018-2023.

S. no	Station codes	Station names	States	River	Frequency	Latitude	Longitude	2018	2019	2020	2021	2022	2023
1	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	Monthly	18.4819	73.8296	460.0	1350.0	1175.0	1112.5	405.0	1037.5

2	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur,Pune	Mahara shtra	Bhima	Monthl y	18.64 57	74.056 4	625. 0	1350 .0	975. 0	870. 0	412. 5	375.0
3	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Mahara shtra	Bhima	Monthl y	18.54 33	73.885	1800 .0	1175 .0	1800 .0	111 2.5	625. 0	1112. 5
4	1191	Bhima at Pargaon (After Confl.with Mula	Mahara shtra	Bhima	Monthl y	18.56 03	74.373 3	450. 0	1075 .0	562. 5	835. 0	232. 5	505.0
5	1192	Mutha),Pargao n, Daund, Pune Bhima after Conf. with Daund, Daund, Pune	Mahara shtra	Bhima	Monthl y	18.46 46	74.583 6	1012 .5	955. 0	625. 0	820. 0	225. 0	497.5
6	1188	Bhima at Narsingpur, (D/S Af.Confl.with R.Nira), Narsingpur, Malshiros, Solapur	Mahara shtra	Bhima	Monthl y	17.98 58	75.116 2	900. 0	1075 .0	275. 0	817. 5	275. 0	250.0
7	28	Bhima at Takli, South Solapur, Solapur	Mahara shtra	Bhima	Monthl y	17.70 37	75.544 6	485. 0	897. 5	450. 0	810. 0	337. 5	315.0
8	1183	Bhima at D/S Of Road Bridge at Gangapur Village,	Karnata ka	Bhima	Monthl y	17.17 92	76.566 6	4800 .0	1850 .0	2850 .0	295 0.0	880. 0	1408 00.0
9	1184	Bhima at Ferozabad Village (D/S),	Karnata ka	Bhima	Monthl y	17.06 93	76.794 3	1700 .0	1070 .0	2210 .0	506 0.0	870. 0	1755 50.0
10	1167	Bhima at D/S of Bdg. Near Yadgir,	Karnata ka	Bhima	Monthl y	16.73 41	77.130 7	3300 .0	2200 .0	2610 .0	186 0.0	255 0.0	1540. 0
11	1888	Bhima River at Confluence of Jewargi Town Sewage Disposal Point	Karnata ka	Bhima	Monthl y	17.04 35	76.814 5	2500 .0	1860 .0	3550 .0	350 0.0	107 0.0	2875. 0
12	2656	Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Mahara shtra	Bhima	Monthl y	18.20 21	75.089	450. 0	1075 .0	535. 0	230. 0	235. 0	260.0
13	1029	Tungabhadra at Haralahalli Bridge,	Karnata ka	Tungab hadra	Monthl y	14.32 54	75.771 1	2100 .0	1550 .0	1550 .0	525. 5	610. 0	935.0
14	29	Tungabhadra at Ullanur	Karnata ka	Tungab hadra	Monthl y	15.49 48	76.692 4	943. 0	898. 0	898. 0	221 0.0	150 5.0	2739. 5
15	38	Tungabhadra at Honnali Bridge	Karnata ka	Tungab hadra	Monthl y	14.23 61	75.659 4	2550 .0	1725 .0	1725 .0	776. 5	520. 0	835.0
16	2767	Tungabhadra at U/S of HpF,	Karnata ka	Tungab hadra	Monthl y	14.51 43	75.785 7	1950 .0	1850 .0	1850 .0	125 0.0	920. 0	910.0

17	2768	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	2450.0	2000.0	2000.0	599.0	1465.0	545.0
18	2769	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	Monthly	14.5265	75.7961	2200.0	1650.0	1650.0	198.0	591.0	825.0
19	2770	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	Monthly	14.5158	75.7979	4610.0	2610.0	2610.0	292.0	7135.0	2365.0
20	2776	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	Monthly	15.4123	76.5863	939.0	884.0	884.0	167.0	1470.0	2200.0
21	2766	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	Monthly	14.5143	75.7857	1400.0	1550.0	1550.0	398.0	747.0	920.0
22	1174	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.8483	78.0349	500.0	650.0	650.0	854.0	1092.0	876.0
23	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	Monthly	15.9445	77.4197	550.0	650.0	650.0	882.0	1211.0	1077.5
24	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kohlapur	Maharashtra	Panchaganga	Monthly	16.7462	74.4457	96.5	101.5	50.0	26.5	29.0	36.0
25	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	Monthly	16.7215	74.5948	92.5	98.0	58.0	26.0	29.0	34.0
26	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6885	74.1695	484.0	101.5	50.5	25.5	24.0	31.5
27	1905	Panchaganga D/S of Kolhapur Town, Uchegaon, Kolhapur	Maharashtra	Panchaganga	Monthly	16.6955	74.275	495.0	134.5	77.0	23.0	27.0	34.5
28	1187	Malprabha at D/S of Khanapur Village,	Karnataka	Malprabha	Monthly	15.6334	74.5103	4545.0	1644.0	1250.0	160.0	1260.0	1260.0
29	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar,	Karnataka	Malprabha	Monthly	15.798	75.1915	1050.0	2050.0	1250.0	126.0	1260.0	1260.0
30	1186	Malprabha at D/S of Aihole Town,	Karnataka	Malprabha	Monthly	16.0093	75.878	940.0	932.5	2050.0	126.0	2400.0	1600.0
31	2764	Malprabha at Badami Bridge,	Karnataka	Malprabha	Monthly	15.8757	75.7223	940.0	1700.0	2050.0	126.0	2400.0	1260.0
32	1387	Bhadra at D/S of Bhadravathi,	Karnataka	Bhadra	Monthly	13.8823	75.7132	4750.0	4950.0	1350.0	174.0	2210.0	1660.0
33	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur,	Karnataka	Bhadra	Monthly	13.9893	75.6837	2610.0	1210.0	2950.0	372.0	1860.0	720.0

34	2765	Bhadra at U/S of Mpm,	Karnataka	Bhadra	Monthly	13.8126	75.7163	1450.0	1300.0	1250.0	388.0	820.0	855.0
35	2771	Bhadra at U/S of Kiocl,	Karnataka	Bhadra	Monthly	13.2128	75.2342	355.0	285.0	245.0	204.0	180.0	230.0
36	4253	Musi sample at bapughat sangam u/s of Musi	Telangana	Musi	Monthly	17.3718	78.4124	400	806	1367	463	480	611
37	4656	River Musi at Moosarambagh Bridge, Hyderabad	Telangana	Musi	Monthly	17.3795	78.5168	723.0	1327	1172	696	661	617
38	2339	River Musi at Nagole, Rangareddy	Telangana	Musi	Monthly	17.3827	78.5578	1124	737	1543	778	693	528
39	4659	Outlet of Nalla Cheruvu, Peerajadiguda	Telangana	Musi	Monthly	17.3856	78.5611	426.0	1373	682	449	548	663
40	4660	River Musi at peerajadiguda	Telangana	Musi	Monthly	17.3831	78.639	391.0	1600	1301	526	545	588
41	1173	Musi d/s at Pratapsingaram, Hyderabad	Telangana	Musi	Monthly	17.3701	78.4698	1128	1014	934	467	455	560
42	4657	River Musi at Pillapalli	Telangana	Musi	Monthly	17.3852	78.7376	414.0	995	787	429	405	576
43	4254	River Musi sample at Rudravelly Bridge	Telangana	Musi	Monthly	17.4068	78.7863	100	71	169	135	108	81
44	4658	River Musi at Valigonda Bridge, Nalgonda	Telangana	Musi	Monthly	17.151	79.5443	971.0	69	99	135	112	92
45	3082	Musi Reservoir at Kasaniguda, Nalgonda	Telangana	Musi	Monthly	17.2476	79.492	132	52	52	63	70	61

Table 17S. The water quality index for different monitoring station in the Krishna river and its major tributaries during 2018-2023.

S. no	Station codes	Station names	States	River	Latitude	Longitude	WQI (2018)	WQI (2019)	WQI (2020)	WQI (2021)	WQI (2022)	WQI (2023)
1	1153	Krishna River at Rajapur Weir, Village-Rajapur, Taluka-Shirol, District-Kolhapur.	Maharashtra	Krishna	16.6301	74.6639	71.6454	71.2168	65.5629	59.9034	65.1528	77.9453
2	36	Krishna at Krishna Bridge, Karad, Karad, Satara	Maharashtra	Krishna	17.2953	74.1888	131.305	120.813	121.423	53.0956	122.483	103.59
3	37	Krishna at Gawali Gally, Miraj, Sangli	Maharashtra	Krishna	16.824	74.6495	70.11	72.7723	74.0531	122.153	74.0251	88.1389
4	1906	Krishna D/S of Islampur, Walwa, Sangli	Maharashtra	Krishna	17.0293	74.3801	203.723	71.8801	72.8977	73.911	69.4471	80.5985

5	1310	Krishna at Kurundwad, Shirol, Kolhapur	Maharashtra	Krishna	16.68 14	74.590 3	70.26 61	67.09 25	62.38 86	57.68 26	67.26 23	78.16 78
6	2190	Krishna River at Wai, Satara	Maharashtra	Krishna	17.94 93	73.891 3	128.7 41	122.7 01	121.7 6	120.8 63	119.7 67	109.8 97
7	2187	Krishna River at Kshetra Mahuli, Mahuli, Satara	Maharashtra	Krishna	17.68 85	74.063 3	118.1 16	132.3 43	121.2 84	110.3 32	116.9 1	106.7 05
8	2188	Krishna River at Krishna-Venna Sangam at Mahuli, Satara	Maharashtra	Krishna	17.68 83	74.063 3	125.9 46	114.9 94	113.7 09	112.1 68	121.2 52	132.5 16
9	1181	Krishna at D/S of Narayanpura Dam,	Karnataka	Krishna	16.24 24	76.370 7	107.0 73	81.46 48	60.94 97	71.26 04	73.93 33	79.14 16
10	1182	Krishna at U/S of Ugarkhurd Barrage,	Karnataka	Krishna	16.64 09	74.821 3	52.70 17	72.58 32	64.31 81	70.10 84	68.19	68.45 97
11	1889	Krishna - Ankali Bridge along Chikkodi Kagwad Road	Karnataka	Krishna	16.55 75	74.679 7	54.22 67	59.93 17	55.74 41	71.57 98	67.97 47	72.68 98
12	1170	Krishna at D/S of Devasagar Bdg.,	Karnataka	Krishna	16.38 05	77.362 7	83.39 84	113.4 1	79.04 83	79.91 86	134.6 89	87.68 03
13	1028	Krishna at Tintini Bridge,	Karnataka	Krishna	16.36 92	76.656 6	79.21 92	76.74 46	70.31 21	84.15 4	109.4 73	84.91 37
14	2781	Krishna at D/S aof Alamatti Dam,	Karnataka	Krishna	16.32 51	75.899 9	97.22 33	83.03 99	65.10 1	71.16	72.86 14	83.69 22
15	1784	Krishna at Thangadi , Mahaboobnagar Dist.	Telangana	Krishna	16.42 42	77.278 9	95.48 49	91.48 93	93.79 9	83.87 95	73.68 75	71.25 67
16	1175	Krishna A/C with Tungabhadra, Sangameshwaram, Kurnool	Andhra Pradesh	Krishna	16.00 19	78.365	62.12 54	55.44 93	62.39 43	67.90 8	65.41 29	60.38 91
17	39	Krishna at Gadwal Bridge	Telangana	Krishna	16.33 88	77.610 2	106.0 08	68.80 8	79.02 99	78.95 6	75.80 25	78.38 36
18	1465	Krishna at Wadapally after Confl. with R. Musi (Shifted From 1220)	Telangana	Krishna	16.69 47	79.689 9	90.12 52	69.90 18	73.85 73	75.23 95	81.43 16	90.14 46
19	1786	Krishna at Vedadri, Kurnool	Andhra Pradesh	Krishna	16.80 19	80.129 6	60.31 52	52.80 95	63.02 81	72.62 42	75.09 19	74.23 32
20	1787	Krishna at Amaravati, Guntur	Andhra Pradesh	Krishna	16.58 26	80.343 5	67.84 06	48.54 28	62.87 05	67.80 95	75.17 91	74.39 6
21	25	Krishna at Vijaywada, Krishna	Andhra Pradesh	Krishna	16.49 25	80.640 8	58.84 68	50.02 88	57.61 19	71.39 06	75.70 42	73.12 9
22	3083	Krishna D/S of Srishailam, Kurnool	Andhra Pradesh	Krishna	16.08 79	78.890 2	57.26 33	53.45 09	55.58 32	65.65 6	60.92 23	56.09 79
23	1782	Krishna at Hamsaladeevi Puligadda aqueduct near Avanigadda(V), Krishna District	Andhra Pradesh	Krishna	16.00 01	81.079 1	157.1 55	118.7 76	123.7 18	117.3 86	115.0 67	108.1 84
24	1189	Bhima at Pune U/S Vithalwadi, Haweli, Pune	Maharashtra	Bhima	18.48 19	73.829 6	147.9 33	374.2 45	284.8 41	156.7 36	125.3 29	408.1 25
25	2655	Bhima River at Koregaon Near Koregaon Bridge, Shirur, Pune	Maharashtra	Bhima	18.64 57	74.056 4	182.7 98	192.5 3	137.4 65	113.4 81	126.5 65	107.1 29

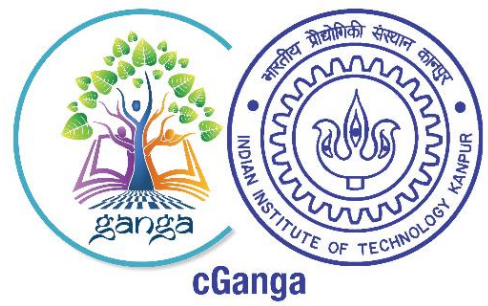
26	1190	Bhima at Pune, D/S of Bundgarden, Yerwada, Haweli, Pune	Maharashtra	Bhima	18.5433	73.885	253.11	228.683	249.228	180.403	216.224	311.145
	1191	Bhima at Pargaon (After Confl.with Mula Mutha),Pargaon , Daund, Pune	Maharashtra	Bhima	18.5603	74.3733	129.579	129.707	177.899	122.855	167.22	161.456
27		Bhima after Conf. with Daund, Daund, Pune	Maharashtra	Bhima	18.4646	74.5836	122.8	123.48	152.203	127.826	161.257	137.634
28		Bhima at Narsingpur, (D/S Af.Confl.with R.Nira), Narsingpur, Malshiros, Solapur	Maharashtra	Bhima	17.9858	75.1162	142.981	158.778	164.455	144.835	192.975	135.107
29		Bhima at Takli, South Solapur, Solapur	Maharashtra	Bhima	17.7037	75.5446	99.4566	128.51	143.45	122.643	136.285	149.317
30	28	Bhima at D/S Of Road Bridge at Gangapur Village, Ferozabad Village (D/S), Bhima at D/S of Bdg. Near Yadgir,	Karnataka	Bhima	17.1792	76.5666	89.9445	88.0834	79.519	83.573	218.262	284.974
31	1183	Bhima at D/S of Confluence of Jewargi Town Sewage	Karnataka	Bhima	17.0435	76.8145	83.8843	94.4706	84.073	82.0117	98.5822	78.1554
32	1184	Disposal Point Bhima River-Backwater of Ujani Dam Near Raw Water Pump House, Kumbargaon, Indapur, Pune	Maharashtra	Bhima	18.2021	75.089	105.896	125.932	129.393	89.0629	148.287	123.021
33	1167	Tungabhadra at Haralahalli Bridge,	Karnataka	Tungabhadra	14.3254	75.7711	78.5433	73.9233	72.8298	78.6382	76.6565	70.5991
34	1888	Tungabhadra at Ullanur	Karnataka	Tungabhadra	15.4948	76.6924	62.4303	88.1371	77.1945	79.405	183.03	114.699
35	1029	Tungabhadra at Honnali Bridge	Karnataka	Tungabhadra	14.2361	75.6594	79.0896	77.8295	68.7257	88.9194	74.2254	65.2786
36	29	Tungabhadra at U/S of Hpf,	Karnataka	Tungabhadra	14.5143	75.7857	78.2233	72.6478	72.4745	77.9661	71.5741	67.3284
37	38	Tungabhadra at D/S of Hpf,	Karnataka	Tungabhadra	14.5143	75.7857	193.409	109.635	103.475	107.471	126.872	110.819
38	2767	Tungabhadra at Jackwell Point,	Karnataka	Tungabhadra	14.5265	75.7961	92.8867	74.5441	78.6119	87.1341	79.1456	90.8157
39	2768	Tungabhadra at Harihar Water Supply Intake,	Karnataka	Tungabhadra	14.5158	75.7979	139.949	113.895	101.902	96.0076	97.0771	116.532
40	2769	Tungabhadra at D/S of Gangawathi,	Karnataka	Tungabhadra	15.4123	76.5863	73.2039	80.4579	77.3731	77.2137	222.231	75.7323
41	2770	Tungabhadra at New Bridge,	Karnataka	Tungabhadra	14.5143	75.7857	77.5821	72.0414	77	75.6513	67.4388	66.3979
42	2776	Tungabhadra at Kurnool U/S, Bhavapuram, Kurnool	Andhra Pradesh	Tungabhadra	15.8483	78.0349	67.8888	63.7612	70.9391	71.8676	76.0701	72.7514
43	2766											
44	1174											
45												

46	1785	Tungabhadra at Manthralayam, Kurnool	Andhra Pradesh	Tungabhadra	15.94 45	77.419 7	72.11 11	57.90 9	67.80 32	69.34 68	81.92 84	67.55 17
47	1311	Panchaganga at Ichalkaranji, Shiradwad, Hatkanangale, Kolhapur	Maharashtra	Panchaganga	16.74 62	74.445 7	66.51 56	70.47 48	65.59 86	61.33 88	69.91 26	81.69 65
48	2163	Panchaganga River at Shirol Near Shirol Intake Well, Kolhapur	Maharashtra	Panchaganga	16.72 15	74.594 8	71.05 05	66.39 87	61.04 17	62.28 94	65.18 21	77.06 21
49	1904	Panchaganga U/S of Kolhapur Town, Balinga, Karvir, Kolhapur	Maharashtra	Panchaganga	16.68 85	74.169 5	204.8 6	67.35 27	57.78 92	55.51 51	68.71 53	72.82 98
50	1905	Panchaganga D/S of Kolhapur Town, Ucheagaon, Kolhapur	Maharashtra	Panchaganga	16.69 55	74.275	210.6 58	67.21 3	60.71 37	62.21 32	67.33 93	75.00 42
51	1187	Malprabha at D/S of Khanapur Village, Malprabha at Water Abstr. Pt. to Hubli, Dharwar, Malprabha at D/S of Aihole Town, Badami Bridge, Bhadra at D/S of Bhadravathi, Bhadra at D/S of Kiocl Road Bridge, near Holehunnur, Bhadra at U/S of Mpm, Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Malprabha	15.63 34	74.510 3	106.3 97	66.78 65	77.87 59	64.83 5	72.01 1	67.14 48
52	1164	Malprabha at Water Abstr. Pt. to Hubli, Dharwar, Malprabha at D/S of Aihole Town, Badami Bridge, Bhadra at D/S of Bhadravathi, Bhadra at D/S of Kiocl Road Bridge, near Holehunnur, Bhadra at U/S of Mpm, Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Malprabha	15.79 8	75.191 5	80.14 99	55.13 05	68.81 22	57.17 65	65.77 72	72.56 95
53	1186	Malprabha at D/S of Aihole Town, Badami Bridge, Bhadra at D/S of Bhadravathi, Bhadra at D/S of Kiocl Road Bridge, near Holehunnur, Bhadra at U/S of Mpm, Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Malprabha	16.00 93	75.878	71.86 87	64.42 6	85.34 88	75.57 67	77.40 88	85.85 69
54	2764	Malprabha at Badami Bridge, Bhadra at D/S of Bhadravathi, Bhadra at D/S of Kiocl Road Bridge, near Holehunnur, Bhadra at U/S of Mpm, Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Malprabha	15.87 57	75.722 3	64.15 21	64.36 49	84.98 91	72.27 6	76.38 79	77.28 06
55	1387	Bhadra at D/S of Bhadravathi, Bhadra at D/S of Kiocl Road Bridge, near Holehunnur, Bhadra at U/S of Mpm, Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Bhadra	13.83 23	75.713 2	143.1 75	135.2 36	99.52 54	117.4 09	72.53 18	70.97 82
56	1169	Bhadra at D/S of Kiocl Road Bridge, near Holehunnur, Bhadra at U/S of Mpm, Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Bhadra	13.98 93	75.683 7	109.2 76	85.87 61	80.85 37	83.77 55	67.27 34	62.23 6
57	2765	Bhadra at U/S of Mpm, Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Bhadra	13.81 26	75.716 3	70.81 89	70.33 19	74.33 4	75.67 15	64.39 43	57.15 2
58	2771	Bhadra at U/S of Kiocl, Musi sample at bapughat sangam u/s of Musi	Karnataka	Bhadra	13.21 28	75.234 2	50.74 82	49.65 32	50.90 28	42.83 13	51.44 29	55.31 47
59	4253	Musi sample at bapughat sangam u/s of Musi	TELANGANA	Musi	17.37 18	78.412 4	232.2 86	356.3 56	633.8 48	240.8 83	265.9 67	290.7 26
60	4656	River Musi at Moosarambagh Bridge, Hyderabad	TELANGANA	Musi	17.37 95	78.516 8	264.0 64	429.0 32	561.1 92	266.4 53	268.5 14	323.5 33
61	2339	River Musi at Nagole, Rangareddy	TELANGANA	Musi	17.38 27	78.557 8	194.7 34	483.8 6	510.8 02	286.8 19	253.6 76	385.8
62	4659	Outlet of Nalla Cheruvu, Peerajadiguda	TELANGANA	Musi	17.38 56	78.561 1	358.4 36	464.0 4	724.4 77	427.9 15	366.3 34	437.6 47
63	4660	River Musi at peerajadiguda	TELANGANA	Musi	17.38 31	78.639	300.7 86	376.3 44	543.2 66	283.8 18	239.3 71	324.8 88
64	1173	Musi d/s at Pratapsingaram, Hyderabad	TELANGANA	Musi	17.37 01	78.469 8	151.0 07	378.2 94	642.6 6	236.6 07	221.2 96	299.1 51
65	4657	River Musi at Pillapalli	TELANGANA	Musi	17.38 52	78.737 6	328.8 69	386.7 72	516.3 9	208.8 44	181.7 41	329.0 76
66	4254	River Musi sample at Rudravelly Bridge	TELANGANA	Musi	17.40 68	78.786 3	286.0 2	59.04 1	58.80 73	58.36 51	84.89 44	46.22 51
67	4658	River Musi at Valigonda	TELANGANA	Musi	17.15 1	79.544 3	232	62.27 08	59.98 95	58.36 51	85.11 35	49.21 57

---

68	3082	Bridge, Nalgonda Musi Reservoir at Kasaniguda, Nalgonda	TELANG ANA	Musi	17.24 76	79.492	145.2 11	66.42 93	56.09 36	48.94 85	82.69 4	51.36 44
----	------	---	---------------	------	-------------	--------	-------------	-------------	-------------	-------------	------------	-------------

---



© cKrishna, cGanga and NRCD, 2025