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Assessment of Water Quality Index of the Chambal River in Kota, Rajasthan

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Abstract: ***major hazard to the world, water poisoning causes more than 14,000 deadly diseases every day, with developing countries like India being disproportionately affected. This review paper summarizes the body of research on the widespread problem of water pollution, detailing its various contaminants (heavy metals, dyes, and organic pollutants), primary sources (industrial, municipal, and agricultural discharges), and catastrophic impacts on aquatic ecosystems and human health. In particular, it discusses existing water quality standards and examines different approaches for evaluating water quality, including the Water Quality Index (WQI) using the CCME method. Making use of several studies that have looked at pollution hotspots, water quality metrics, and suggested management techniques, the paper places the local issues within the larger national and international water crises, utilizing the Chambal River in Kota, Rajasthan, as a case study. In order to safeguard current and future generations, the assessment emphasizes the critical necessity for thorough pollution control, ongoing monitoring, and sustainable water resource management.***
Keywords: WQI, CCME, WHO, Dye, Pollutants, Heavy Metal.

I. INTRODUCTION

4The aim of this paper is to assess the water quality index using the CCME method in Chambal river, Kota Rajasthan. Water pollution is a critical global issue, posing severe threats to ecosystems and human health, with over 14,000 disease-related deaths reported daily—most notably in developing countries like India. This review highlights the alarming state of water contamination, focusing on pollutants such as heavy metals, dyes, and organic compounds, and identifies their primary sources, including industrial, municipal, and agricultural effluents. Emphasis is placed on water quality standards and assessment techniques like the CCME-based Water Quality Index (WQI). Using the Chambal River in Kota, Rajasthan, as a case study, this paper underlines the urgent need for sustainable water management and pollution mitigation strategies.

Water is a vital resource, and one of the biggest worldwide issues of the twenty-first century is its contamination. According to the World Health Organization (WHO), 5.2 billion people have access to safely treated water, while 1 billion people do not have this basic need. The repercussions are severe; in underdeveloped nations, waterborne illnesses are thought to kill 2.2 million people each year [6]. This problem is particularly severe in India, the second-most populous country in the world, where more than 70% of the freshwater is unsuitable for human consumption.

The primary drivers of water contamination are uncontrolled discharges of industrial and municipal waste, coupled with inadequate wastewater treatment infrastructure [6]. Nearly two-thirds of the pollution that is deposited into aquatic bodies comes from industry alone, with an astounding 80% going untreated. Given that water pollution was directly responsible for 1.8 million deaths globally in 2015, it is predicted that this environmental degradation will pose a major hazard to human life during the next ten years [37]. Beyond public health, the wide-ranging effects have a significant negative influence on environmental integrity, economic stability, and national development [34]. Significant risks to the world and its people are posed by factors such fast urbanization, population growth, increased industrial production, and climate variability, all of which worsen the deterioration of water quality [34].

Generation after generation, the long-term consequences of water pollution show up as a wide range of severe illnesses. Contaminated water in India has been linked to a number of harmful illnesses, including as cancer, birth defects, and ailments of the skin, lungs, brain, kidneys, and liver [15]. Pune's waterways are among the most polluted in India, according to a research, mostly as a result of raw sewage and inadequately treated wastewater discharge [27].

The difficulties experienced by Kota city, a major center of industry and education in Rajasthan where the Chambal River serves as a crucial water source, are particularly examined in this paper. Encroachment, illegal water diversion, untreated industrial and domestic waste discharge, and solid waste dumping all put tremendous strain on the river here [30].

Figure 1: Chambal River with Thermal Power Plant

A. Water Contamination And Its Sources

For people and ecosystems around the world to survive, clean water is essential. However, the increasing urbanization, industrialization, population increase, and careless exploitation of natural resources have all contributed to the steady decline in water quality over the past few decades [7]. With a broad range of pollutants including illnesses, heavy metals, dyes, radionuclides, plastics, nanoparticles, biocides, organic compounds, pharmaceuticals, and excess nutrients, the variety of contaminants presents a challenging problem [36].
Only 2% of the water on Earth is freshwater, and only 0.036% of that is fit for human use; the remainder is trapped in arctic ice, groundwater, and wells [26]. The remaining 98% is salty seawater that isn't fit for human consumption.
Both point and non-point sources can contaminate water [29].
Point Sources are recognizable, precise sites where pollutants are released.

- The effluent from industrial and public wastewater treatment facilities.
- Leachate and overflow from mines, oil fields, and non-sewer industrial locations.
- Animal feedlot runoff and intrusion.
- Sewer outfalls from major cities with a population of 100,000 or more.
- Overflows of combined sewers during hygienic events and rainstorms.
- Debris from huge building sites (more than two hectares).

Non-point sources are diffuse sources that can't be linked to a specific discharge location since they come from a wide area.

- Exiting pasture and range lands.
- Runoff from sewer-and non-sewer urban areas with fewer than 100,000 residents
- Runoff from defunct mines
- leachate from septic tanks & overflow from malfunctioning septic systems
- Pollutants produced by land-related operations such construction, canal or land development, logging, and wetland conversion

B. Water Quality Index (WQI)

The Water Quality Index (WQI) is a crucial numerical scale that simplifies the communication of water quality status by integrating several water feature criteria into a single, complete score [27]. This score is crucial for determining the health of freshwater ecosystems and directing decisions about the management of water resources.

The WQI is frequently used to identify and assess overall water quality and pollution [35][24]. Using 10 typical water quality metrics, such as dissolved oxygen (DO), pH, coliforms, electrical conductivity (EC), alkalinity, and chlorides, Horton initially proposed the WQI idea in the United States in 1965 [4]. Many specialists subsequently made changes to this index, which resulted in the creation of different WQI models, including the one developed by Brown in 1970 [2].

Evaluate water quality index by using method below

1) NSF-WQI (National Sanitation Foundation method –water quality index)
2) O-WQI (Oregon Water Quality Index)
3) WA-WQI (weighted arithmetic water quality index)
4) CCME-WQI (the Canadian Council of Ministers the environment index)

C. *Effects Of Water Pollution*

The impacts of water contamination are pervasive and severe, affecting various facets of life and the environment:

1) The impacts of water contamination numerous industries generate polluted water that contains harmful chemicals that can alter the water's color, add more minerals, change its temperature, and endanger aquatic life [7].
2) Serious health issues and diseases are caused by infections, some water contaminants, dangerous bacteria, and chemicals found in domestic sewage water. Subterranean water that sewer line leaks have contaminated is unsafe for human consumption. Water that is left on the surface when a leak is not fixed promptly might serve as a haven for mosquitoes and other insects [23].
3) Hazardous chemicals that can react with water and add toxic elements can cause major health issues. These compounds are found in the basic materials of underground coal and other minerals that are extracted [12].
4) Some nations discard domestic waste—including paper, plastic, food, rubber, aluminum, and glass into the ocean. The fact that oil spills in the ocean do not dissolve in water poses a serious risk to marine life. Fish, birds, and sea otters are among the marine animals that suffer as a result [22].
5) Acid rain is created when hazardous chemicals react with water vapor, endangering both aquatic and terrestrial life.

D. *Water Quality Standard Parameters*

To ensure water safety, various parameters are monitored and compared against established standards. The Indian Standard (IS 10500:2012) and WHO specifications for drinking water [33] provide acceptable and permitted limits for physical, chemical, and bacteriological parameters.

Table 1: Physical Parameters of Drinking Water

S.No.	Specific (mg/l)	Acceptable limit	Permitted limit
1	Odor	<5 hzn	<5 hzn
2	Taste	unobjectionable	unobjectionable
3	Color	5	15
4	Turbidity (NTU)	1	5
5	PH	>6.5 &<8.5	NR
6	TDS	500	2000
7	EC (mhos/cm)	300	750

Table 2: Chemical Parameters of Drinking Water

S.No.	Specific (mg/l)	Acceptable limit	Permitted limit
1	Aluminium	.03	.2
2	Ammonia	<.2	<.2
3	Barium	.7	NR
4	Boron	.5	1
5	BOD	NIL	NIL
6	COD	<10	<10
7	Calcium	75	200
8	Chloride	250	1000
9	Copper	.05	1.5
10	DO	3-5	3-5
11	Fluoride	1	1.5
12	Free residual chlorine	0.2	1.0
13	Fe	.3	NR
14	Mg	030	0100
15	Mn	.1	.3
16	Nitrate	45	NR
17	Phenol compound	.001	.002
18	Selenium	.01	NR
19	Silver	.1	NR
20	Sulphate	200	400
21	Total alkalinity	200	600
22	Total hardness	300	600
23	Zinc	5	15
24	Mercury	.001	NR
25	Cadmium	.01	NR
26	Arsenic	.05	NR
27	Cyanide	.05	NR
28	Chromium	.05	NR
29	Lead	.05	NR

Table 3: Bacteriological Quality of Drinking Water

S.No.	Specific	Acceptable limit	Permitted limit
1	E-Coli organism MPN/100ML	It cannot be found in any 100 ml sample.	NIL
2	Coliform organism MPN/100ML	It cannot be found in any 100 ml sample.	500

E. Study Area: Chambal River, Kota

The Chambal River in Kota, Rajasthan, India, serves as the specific study area for assessing water quality. Located approximately 240 kilometres from Jaipur, Kota is a prominent city with over 1.5 million residents (as of 2024), known for its industrial activities, educational coaching centres, unique paintings, Kota stone, and textile industries [14]. The city's geographical coordinates are 75.833 E longitude and 25.18 N latitude.

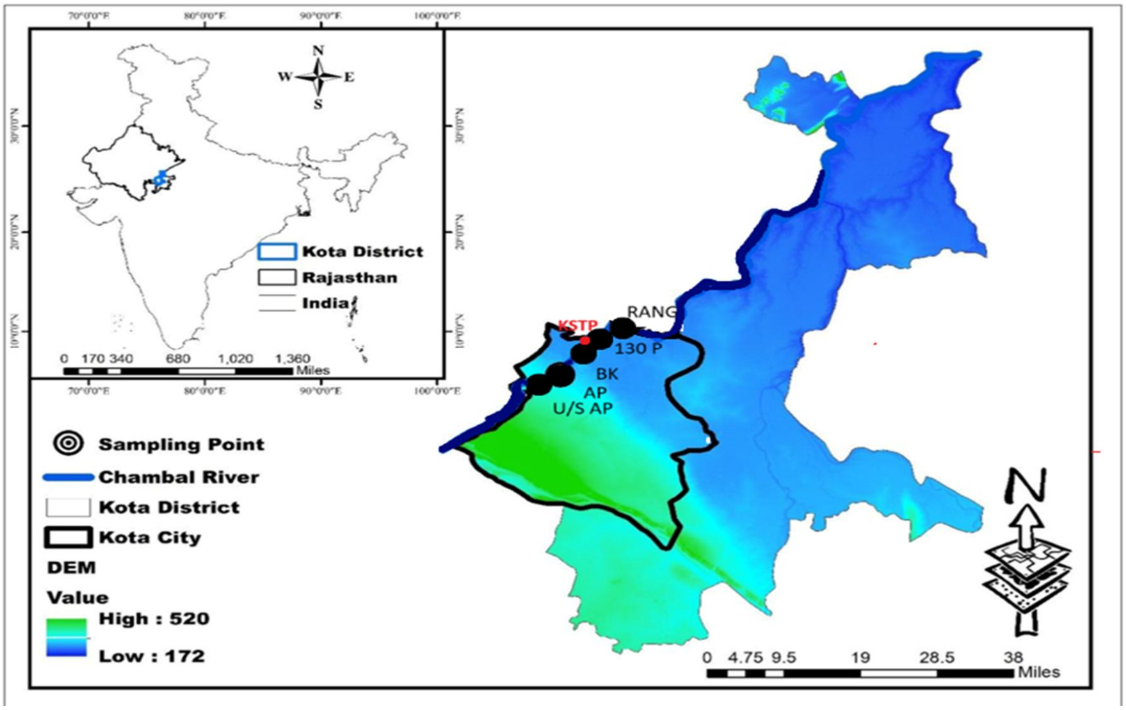

Figure 2: Chambal River map in Kota District

Sampling Points: Marked with black circles, indicating the specific locations where water samples are to be collected. These include RANG (Rangpur), 130 P (130 MLD plant), BK (Bhitriya Kund), AP (Akhelgarh plant), and U/S AP (Upstream of Akhelgarh plant), suggesting a distribution of monitoring sites around potential pollution sources.

The focus of the planned study is to assess the water quality of the Chambal River in Kota city using the CCME method of the Water Quality Index. This involves a comparative analysis of water quality at different locations upstream and downstream of a thermal power plant, correlating with the sampling points shown in Figure 2. Water samples will be collected monthly from March 2024 to Feb 2025, covering pre-monsoon, monsoon, and post-monsoon periods, to analyze 17 key water quality parameters.

F. Objective Of The Study

To evaluate the water quality index's with the help of the CCME method and a comparative analysis at different locations near the thermal power plants.

II. LITERATURE REVIEW

A comprehensive literature review is essential for understanding the existing body of knowledge, identifying research gaps, and informing future methodologies. This section summarizes relevant studies on water quality assessment and pollution.

Earlier studies on river pollution highlighted significant concerns: Sunil Kumar Karn et al. (2001) found high BOD and coliform levels in the Yamuna, Buriganga, and Baghmati rivers, indicating severe organic pollution [1]. Bordalo A. et al. (2001) attributed pollution in the Bangpakong River to urban wastewater, industrial discharges, and agricultural runoff, threatening aquatic ecosystems and human consumption [2]. V. Simeonov et al. (2003) emphasized the need for long-term monitoring, biological data, and health risk assessment in Northern Greece's surface waters [3]. Y. Ouyang et al. (2006) noted seasonal variations in water quality and suggested broader evaluations including biological assessments and climate change impacts [4].

Several studies have specifically investigated the Chambal River. D.N. Saksena et al. (2008) observed generally good water quality in the National Chambal Reserve (Madhya Pradesh segment) from 2003-2004, characterizing it as oligosaprobic (pollution-free), with high DO and low BOD/COD, supporting diverse aquatic species [5]. Naresh Singh et al. (2014) also reported excellent water quality in the Chambal River, suitable for bathing, irrigation, and aquaculture, and potable with minor treatment [12]. AMIT KUMAR et al. (2014) used NSF-WQI to assess the Chambal River in Madhya Pradesh, confirming its suitability for various uses and aquatic life conservation [13]. However, PARVEEN KUMAR et al. (2018) investigated heavy metal concentrations around the Kota Super Thermal Power Plant, examining the impact of coal burning and fly ash on both surface and groundwater, indicating localized concerns [25].

Beyond the Chambal, broader issues of water contamination are evident. A. Agrawal, R. S et al. (2010) explored widespread pesticide contamination in Indian water supplies due to agricultural practices, warning of their persistent nature and harmful effects on aquatic life and human health [6]. Oladele Osibanjo et al. (2011) found substantial organic contamination in River Alaro and River Ona from industrial discharges, impacting residential and agricultural uses [7]. Singh Jaspal et al. (2012) observed mild contamination in a river from domestic sewage, agricultural runoff, and industrial discharges, making it unfit for agriculture due to high alkalinity and industrial pollutants [8].

The application of Water Quality Index methods is a recurrent theme. V. Calmuc et al. (2018) compared various WQI determination techniques (British Columbia, CCME, NSF), emphasizing that local conditions and water use should guide the choice of approach, and advocating for generic WQI models that account for new pollutants and regional variances [27]. Chandra D. S. et al. (2017) utilized the Weighted Arithmetic Water Quality Index method to classify water quality from good to unfit based on parameters like pH, DO, BOD, NO3, and TDS [24]. Venkatramanan S et al. (2016) used CCME-WQI with GIS to map groundwater quality in a research area, identifying impacts from salty water intrusion, localized pollution, and agricultural runoff [20]. Similarly, V. M. Wagh et al. (2017) applied CCME WQI to categorize groundwater quality in a basin, noting changes due to natural and anthropogenic causes like waste management, industrial discharge, and agricultural runoff [21]. Ruth Olubukola Ajoke Adelagun et al. (2021) also employed WQI to assess water quality in Nigeria, emphasizing the need for better management and policy implementation [35].

Studies on heavy metal contamination are also prominent. A. Akobundu N. et al. (2012) applied the Heavy Metal Contamination Index to Nigeria's Aba River, revealing high contamination levels, especially near industrial operations, and advocating for urgent pollution control [10]. Soma Giri et al. (2013) found both natural and man-made heavy metal pollution in the Subarnarekha River, with higher levels in industrial and mining areas [11]. Atish Prasad et al. (2020) reported heavy metal concentrations (iron, manganese, zinc, chromium, lead) in the Upper Ganga River often exceeding WHO and BIS standards, linking them to non-carcinogenic health risks from industrial waste and untreated trash [30]. C. Zamora-Ledezma et al. (2021) investigated heavy metals (As, Pb, Cd, Hg, Cr) in water bodies and contrasted traditional remediation methods with novel approaches like nanomaterials and bioremediation [28].

The impacts of pollution on public health and the environment are consistently highlighted. J. Halder et al. (2015) emphasized that drinking tainted water leads to long-term brain problems (from lead and arsenic), skin infections, and gastrointestinal disorders, emphasizing the importance of waste management, pollution control, and water purification [15]. C. P. Liyanage et al. (2017) linked increasing water pollution (nitrates, phosphates, heavy metals, pathogens) to poor waste management and population growth, suggesting public awareness and urban design solutions [22]. H. R. Bharathi et al. (2017) found many water bodies unfit for human consumption due to domestic sewage, farm runoff, and industrial effluents, with high nitrate and TDS levels contributing to poor water quality [23].

Further research includes Mohd Yawar Ali Khan et al. (2015) who investigated water quality deterioration in the Ramganga River, identifying significant organic contamination and suggesting the need for better management plans [16]. R. Ramya Priya et al. (2016) explored natural and man-made factors affecting the Cauvery River's water quality, noting spatial and temporal variations linked to pollution sources [19]. B.T. P. Jian et al. (2020) used WQI and PAHs to assess river water quality affected by treated landfill leachate, underscoring the necessity of improved monitoring and treatment [34]. J. O. Ighalo et al. (2020) identified water pollution hotspots across Nigeria and analyzed their effects on health, ecology, and water supplies, recommending targeted solutions [32].

The literature consistently points to the complex interplay of various factors contributing to water pollution and the necessity of comprehensive approaches for assessment and mitigation. Anjali Puri et al. (2015) even touched upon an unexpected social impact, highlighting the negative aspects of competitive exam preparation in Kota, leading to student stress and mental health issues [14], though not directly related to water quality, it provides context for the city's overall environmental and social pressures.

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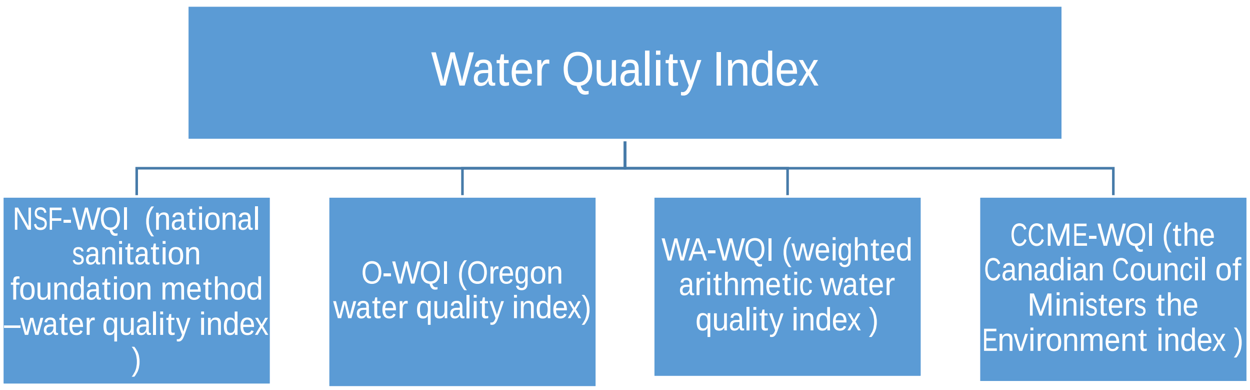
III. RESEARCH METHODOLOGY& DATA OBSERVATIONS

Quantitative research methodology entails the systematic investigation of phenomena through the meticulous collection and analysis of numerical data. This approach is employed to quantify variables, measure relationships, and test hypotheses using an array of statistical tools and techniques. Typically, it involves structured data collection methods, such as surveys, experiments, or observational studies, to procure data that can be rigorously analyzed mathematically. Quantitative research endeavors to ensure the objectivity, reliability, and generalizability of results by employing standardized procedures and often involving larger sample sizes. By concentrating on measurable data, this methodology provides profound insights into patterns, correlations, and trends, thus enabling researchers to draw empirically backed conclusions.

There are four methods to evaluate the water quality index

1) NSF-WQI (national sanitation foundation method –water quality index)
2) O-WQI (Oregon water quality index)
3) WA-WQI (weighted arithmetic water quality index)
4) CCME-WQI (the Canadian Council of Ministers the Environment index)



In this study, the most appropriate method(CCME –WQI) among the four available techniques has been selected and implemented for the determination of the Water Quality Index (WQI) of the Chambal River at different locations in Kota, Rajasthan. This methodology utilizes seventeen distinct water quality parameters to ensure a comprehensive and robust assessment of the water quality.

A. *The Canadian Council of Ministers of the Environment Index (CCME-WQI)*

The index created by the British Columbia Ministry of Environment, Lands, and Parks serves as the foundation for the CCME WQI. Three elements are combined to create the CCME WQI

1) The no. of criteria that are not followed (Scope)
2) The frequency of noncompliance with the guidelines (frequency)
3) The magnitude of noncompliance (amplitude)

A single number between 0 and 100 that characterizes the quality of the water is obtained by adding the three vectors (scope, frequency, and amplitude).

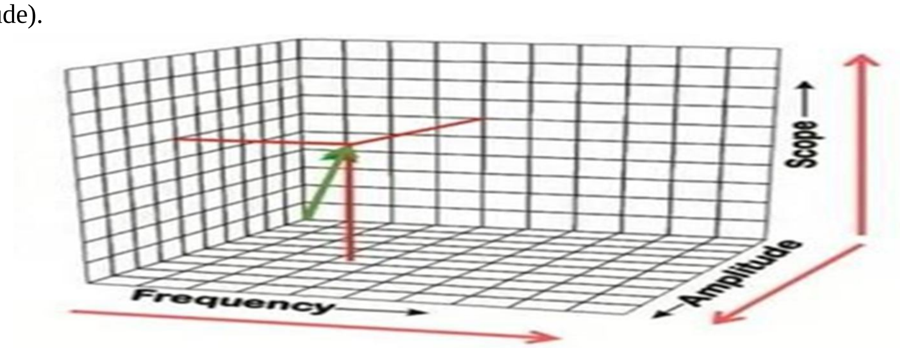


Figure 3: CCME Model

The Canadian Water Quality Index (CWQI) is determined by three factors: -

$$WQI = 100 - \left(\sqrt{\frac{{F_1}^2 + {F_2}^2 + {F_3}^2}{1.732}}\right)$$

Where: $F1$ = Represent Scope: The proportion of variables that are higher than the recommended level of Several factors whose goals are not fulfilled.

Calculate F1 (represent scope) by using the below formula

F 1 = [Number of unsuccessful variables / Total number of variables] *100

F2 = Represent Frequency:- Each variable's section of individual tests that.

Exceeded the recommended threshold or the rate at which the goals are not achieved.

Calculate F2 (represent frequency) by using the below formula

F2 = [Number of unsuccessful tests/Total number of tests]*100

F3 = Represent Amplitude: The degree to which the unsuccessful test surpasses the recommendation or the The degree to which the goals are not achieved.

Calculate the Excursion by using the below formula

a) When the test value can't get above the goal:-

Excursion = [Unsuccessful test value/Objective]-1

b) For situations where the test value cannot be less than the goal:-

Excursion = [objective /Unsuccessful test value]-1

$$\text{Normalized sum of excursions } (nse) = \sum_{i=1}^{n} \frac{excursions}{No\ of\ tests}$$

Then, using the formula below, determine the normalized sum of excursion (NSE).

Calculate final F3 (amplitude) by using below formula

Finally, calculate the water quality index by using the CCME formula given

$$F_3 = \left[\frac{nse}{0.01\,nse + 0.01}\right]$$

To make sure the index fluctuates between 0 and 100, a scaling factor (square root of 3) of 1.732 is used.

$$WQI = 100 - \left(\sqrt{\frac{{F_1}^2 + {F_2}^2 + {F_3}^2}{1.732}}\right)$$

Table 4: Water Quality Rating as per CCME-WQI Model

CCMEWQI Value	Rating of Water Quality	Significance
95-100	Excellent	It is safeguarded by a virtual absence of threat or harm, with conditions very similar to natural or pristine levels.
80-94	Good	It is safeguarded with minimal danger or impairment, and circumstances hardly ever deviate from ideal or natural levels.
65-79	Fair	Although generally protected, it is periodically endangered or compromised, and circumstances can deviate from the ideal or natural state.
45-64	Marginal	It is frequently threatened or degraded, and conditions frequently depart from natural or desirable levels.
0-44	Poor	It is virtually always threatened or degraded,situations typically deviate from natural or desirable levels

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Benefits:-

- ✓ It is easy to compute has a low degree of sensitivity to missing data, and is highly adaptable to various water usage.
- ✓ It is appropriate for the study of data obtained through automatic sampling.

Demerit: Every variable is equally important in determining the index.

B. Sampling Points

Five sampling points in the u/s &d/s thermal power plant were selected for this work.

Table 5: Sampling Point

Sample Point		Sampling Points Position	Total Sampling
U/S AKHELGARH PLANT		Upstream	12
AKHELGARH PLANT		Upstream	12
BHITRIYA KUND		Upstream	12
130 mld plant	Downstream	12	
Rangpur	Downstream	12	

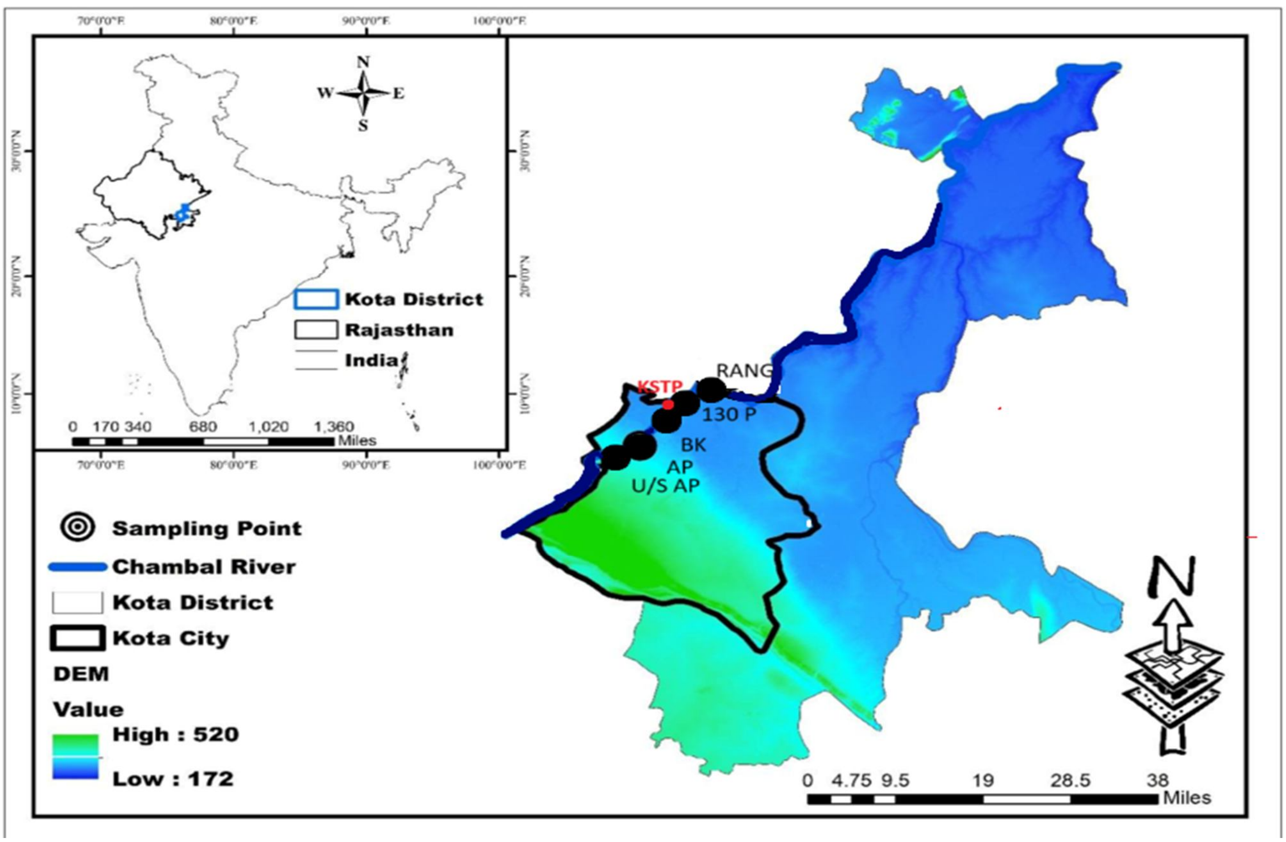

Figure 4: Sample Location

C. Data Observations

From March 2024 to February 2025, data on a number of water quality parameters were observed at U/S Akelgarh Plant, Akhelgarh Plant, Bhitriya Kund, 130 mld plant Rangpur, including B.O.D., C.O.D., Chloride, Conductivity, Dissolved Oxygen, Alkanity Methy Orange, Fluoride, Magnesium, Nitrate, pH, Sulphate, Total Aluminum, Total Coliform, Total Dissolved Solids, Total Hardness, suspended solid, and Turbidity.

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		PARAMETRS	PH	TURBIDITY	ALKANITY METHY ORANGE (CACO3)	TOTAL ALUMINIUM	SUSPENDED SOLID	TOTAL HARDNESS	MAGNISIUM HARDNESS	EC	TDS	CHLORIDES	NITRATES	SULPHATE	DO	BOD	COD	FLURIDE	COLIFORM
		STAND	8.5	5	600	0.2	1	600	150	300	2000	250	45	400	5	3	10	1.5	500
	PRE Mansoon	Mar-24	8.09	1.09	120	0.05	0.45	140	56	460	274	40	0.39	50	6.9	3.5	12.1	0.261	2400
		Apr-24	8.34	2.01	124	0.06	0.56	132	60	468	281	40	0.81	45	8.1	3.2	10.5	0.248	2400
		May-24	8.7	1.04	120	0.05	0.61	269	56	448	269	44	1	63	5.2	3.5	12.1	0.231	2400
		Jun-24	8.08	12.57	116	0.06	0.5	136	67	458	275	44	1	40	5.2	4.1	11	0.256	2400
	DURING MANSOOI	Jul-24	8	10.2	110	0	0.52	100	56	360	223	40	3	45	7.2	3.1	6.3	0.308	2400
		Aug-24	7.56	3.18	104	0	0.57	112	50	334	209	32	1	40.2	6.7	3.4	8	0.177	2400
AKHIGARH		Sep-24	7.6	9.2	110	0.04	0.45	130	55	384	240	36	1	25.2	7.3	3.6	6.3	0.199	2400
PLANT		Oct-24	7.58	9.3	120	0.03	0.46	110	60	376	226	36	3	30.2	5.5	3.1	6.8	0.23	2200
	POST MANSOON	Nov-24	7.98	2.9	110	0.03	0.41	120	50	362	217	30	0	44.3	6.8	3.5	5.7	0.18	2400
		Dec-24	8.54	3.1	110	0.04	0.65	130	60	478	270	40	1	45	9.2	4.1	13.1	0.26	2400
		Jan-25	7.93	3.29	116	0.03	0.3	148	62	480	286	36	0.67	45	8.1	4.2	11	0.271	1100
		Feb-25	7.84	2.78	120	0.04	0.6	148	65	465	277	40	0.53	67	8.2	3.1	10.2	0.265	1100
	PRE MANSOON																		
		Mar-24	8.9	4.5	104	0.145	0.98	97	78	690	430	57	1.8	57.4	5.9	1.3	17.1	0.45	2200
		Apr-24	8.9	8.2	98	0.05	1.4	104	98	510	320	65	0	54.3	4.4	1.7	15.2	0.34	2400
		May-24	8.4	5.3	140	0.1	1.8	110	35	520	340	45	1.6	70.2	6.2	2.9	14.2	0.1789	2200
		Jun-24	8.1	15.7	110	0.04	1.1	98	56	670	420	87	2.9	65.2	6.1	2.5	16.1	0.198	2400
BHITRIY	DURING MANSOOI	Jul-24	7.8	8.1	135	0.01	0.78	140	70	544	340	40	0	40.5	7.1	3.5	8.1	0.176	2400
kund		Aug-24	7.53	10.4	104	0.03	1.4	108	60	324	203	32	1	35.2	6.7	2	16.8	0.172	2400
		Sep-24	7.7	12.45	119	0.06	2.3	104	40	864	540	28	3	34.2	7.1	1	16.2	0.181	2400
		Oct-24	7.96	13.2	110	0.07	1.8	120	50	360	223	30	0	30.1	6.8	2	15.6	0.167	2400
	POST MANSOON	Nov-24	8.01	2.9	100	0	0.51	120	50	370	229	40	0	43.1	7.1	3.2	5.8	0.2	2200
		Dec-24	8.7	4.1	110	0.023	0.56	90	50	670	420	56	1.4	45	6.6	3.1	12.4	0.34	2400
		Jan-25	8.56	2.1	145	0.05	0.45	160	80	720	450	76	1.5	49.2	4.1	3.1	13.5	0.2	2400
		Feb-25	8.8	6.7	123	0.04	0.89	110	70	520	340	49	1.7	56.2	5.1	3	16.1	0.45	2400
	PRE MANSOON	Mar-24	8.1	2.7	120	0	0.6	140	60	380	266	50	1	64	6.9	3.5	5.8	0.29	2400
		Apr-24	7.86	3.4	130	0.05	0.64	140	60	430	301	60	2	50	6.7	4.2	6.4	0.278	2400
		May-24	7.81	6.3	130	0.07	0.51	140	60	450	315	60	2	54	6.1	4.1	7.9	0.244	2200
		Jun-24	7.98	13.1	130	0.03	0.35	130	50	470	329	60	1	60	6.1	3.5	7.1	0.27	2400
	DURING MANSOOI	Jul-24	7.93	8.2	130	0.21	0.4	130	60	515	322	50	0	40.1	6.1	4.2	17.8	0.87	2200
		Aug-24	8.61	15.6	100	0.02	0.56	110	55	379	237	40	0	37.2	4.2	3.2	16.2	0.76	2400
PLANT		Sep-24	7.96	15.6	110	0.07	1.02	110	40	360	223	40	0	35.1	6.7	3.2	15.5	0.178	2400
130 MLD		Oct-24	8.98	3	110	0.05	0.41	120	50	350	217	40	1	30	6.9	3.1	15.7	0.182	2400
	POST MANSOON	Nov-24	7.96	2.5	110	0.02	0.39	110	40	360	223	40	0	80.2	6.8	3.2	5.7	0.2	2200
		Dec-24	8.8	3.1	120	0	0.42	140	50	448	269	60	1	80	7.9	3.6	7.9	0.278	2400
		Jan-25	8.03	2.6	120	0	0.54	120	50	310	217	30	0.45	6	6.9	4.1	5.6	0.268	2200
		Feb-25	8.15	2.9	120	0.03	0.54	130	50	360	252	40	0.56	45	7.1	4.5	6.3	0.28	2400
	PRE MANSOON																		
		Mar-24	8.8	6.7	104	0.03	0.65	152	65	625	412	92	1.7	60.5	6.4	1.4	10.2	0.54	350
		Apr-24	8.8	9.3	92	0.04	0.56	180	79	629	409	88	1.8	85.8	4.8	2.3	14.2	0.51	430
		May-24	8.9	15.4	96	0.15	0.45	168	67	698	448	96	1.2	68.8	4.5	2.6	17.7	0.48	430
		Jun-24	8.6	25.4	100	0.25	0.42	160	68	697	453	88	1.4	65.4	5.1	2.7	19	0.43	540
ragnpur	DURING MANSOOI	Jul-24	8.4	12.3	104	0.01	0.45	132	64	414	275	60	1.2	35.1	5.3	2.5	17.9	0.54	540
		Aug-24	7.9	17.6	110	0	0.44	124	56	388	259	56	1.7	27.8	5.2	2.3	15.3	0.47	430
		Sep-24	7.3	14.1	130	0.02	0.67	136	52	318	215	44	2.6	21.6	5.4	2.8	21.1	0.35	430
		Oct-24	8.3	5.7	140	0.3	0.87	160	56	362	243	48	2.9	26.1	6.2	2.8	19.8	0.25	430
	POST MANSOON	Nov-24	8.2	5.8	108	0.01	1.1	135	55	511	336	55	1.4	59.6	5.6	2.6	19.6	0.38	430
		Dec-24	8.3	6.9	110	;04	0.45	183	81	580	377	64	2.3	79.4	6.7	2.2	16.1	0.53	430
		Jan-25	8.1	7.9	110	0.03	0.43	180	89	768	480	67	1.56	100.8	4.8	2.1	16.5	0.67	540
		Feb-25	8.8	8.2	90	0.23	0.6	187	76	765	440	65	1.6	98.34	5.1	3.1	15.1	0.65	450
	PRE MANSOON																		
		Mar-24	8.5	2.9	56	0	0.3	120	64	332	216	45	0.9	28.4	6.8	1.3	7.8	0.34	79
		Apr-24	8.2	3.6	56	0.03	0.25	132	57	371	246	35	0.8	32.4	6.5	1.4	7.3	0.25	63
		May-24	8.3	4.5	64	0.015	0.4	124	58	406	269	60	0.8	25.8	6.2	1.2	7.8	0.31	63
		Jun-24	8.4	4.9	60	0	0.67	120	68	394	261	46	0.7	29.2	6.3	1.5	9.2	0.38	84
	during mansoon	Jul-24	8.2	6.2	110	0	0.52	100	52	360	214	52	0.7	19.2	5.8	1.3	9.2	0.38	210
		Aug-24	7.9	8.2	108	0	0.57	96	32	334	145	24	1.1	14.9	6.4	1.1	8	0.32	280
		Sep-24	7.2	7.2	120	0.02	0.67	104	36	384	149	24	1.1	11.9	6.5	0.2	9.1	0.27	220
		Oct-24	8.1	1.9	123	0.04	0.44	144	56	370	241	56	1.2	19.2	7.1	1.3	10.5	0.24	210
u/s STREAM		Nov-24	8.1	3.9	109	0.02	0.41	174	51	350	246	36	1.9	14.9	6.1	1.5	10.6	0.25	246
AKHILGARH		Dec-24	7.9	2.2	129	0.01	0.35	123	66	380	221	38	0.8	23.4	6.9	1.4	10.2	0.33	221
		Jan-25	8.1	3.6	60	0.02	0.15	104	60	327	219	50	1	20.9	6.6	1.1	5.2	0.24	33
		Feb-25	8.3	2.4	64	0.015	0.45	116	90	371	244	40	1.4	33	6.6	1.2	8.3	0.33	38

IV. RESULT & DISCUSSION

The Result and Discussion section is a critical component of any research or analytical report. It presents the findings derived from the collected data and provides a detailed interpretation of their significance. This section not only highlights key trends, patterns, and anomalies but also compares them with existing standards or previous studies to draw meaningful conclusions. Through a thorough discussion, it connects the results with the research objectives, providing insights into the implications of the data. The analysis also helps identify challenges, potential areas for improvement, and policy recommendations based on the observed outcomes

A. Computing Water Quality Index

In order to calculate the Water Quality Index (WQI), a number of physio-chemical parameters are examined, including turbidity, dissolved oxygen, pH, and nitrates. The weight of each parameter is determined by its importance. A single index number that reflects the water's suitability for both ecological and human use is created by combining the weighted values. We are used CCME Method for calculating of water quality index.

1) Water Quality Index during Pre-Monsoon

Five distinct sites' water quality statuses are represented by the provided CCME Water Quality Index (CCMEWQI) values. Of them, U/S AP (Up Stream Akhelgarh Plant) has an excellent water quality grade of 95.13, which indicates that there is little pollution and that the ecological conditions are healthy. Locations AP (Akhelgarh Plant) (83.72), BK(Up Stream Akhelgarh Plant) (81.72), and 130 P (130 mld plant) (86.46) are classified as Good, indicating a small amount of human influence but still suitable for the majority of applications. RANG (Rangpur) CCMEWQI value of 79.13, on the other hand, puts it in the Fair category, which denotes moderate pollution levels that can affect aquatic life and necessitate treatment for certain applications. Potential causes of pollution close to RANG (Rangpur) are highlighted by the statistics, which show a general trend of declining water quality from upstream to downstream. To stop more deterioration, ongoing monitoring, pollution prevention strategies, and wastewater treatment are crucial. Although the overall quality of the water is excellent, proactive steps are required to ensure environmental sustainability, particularly in the RANG (Rangpur) area.

Table 6: CCME-WQI During Pre-Monsoon

CCMEWQI Value					
Rating of Water Quality /location	**AP**	BK	130 P	RANG	U/S AP
95-100 Excellent					95.13
80-94 GOOD	83.72	81.72	86.46		
65-79 FAIR				79.13	
45-64 MARGINAL					
0-44 POOR					

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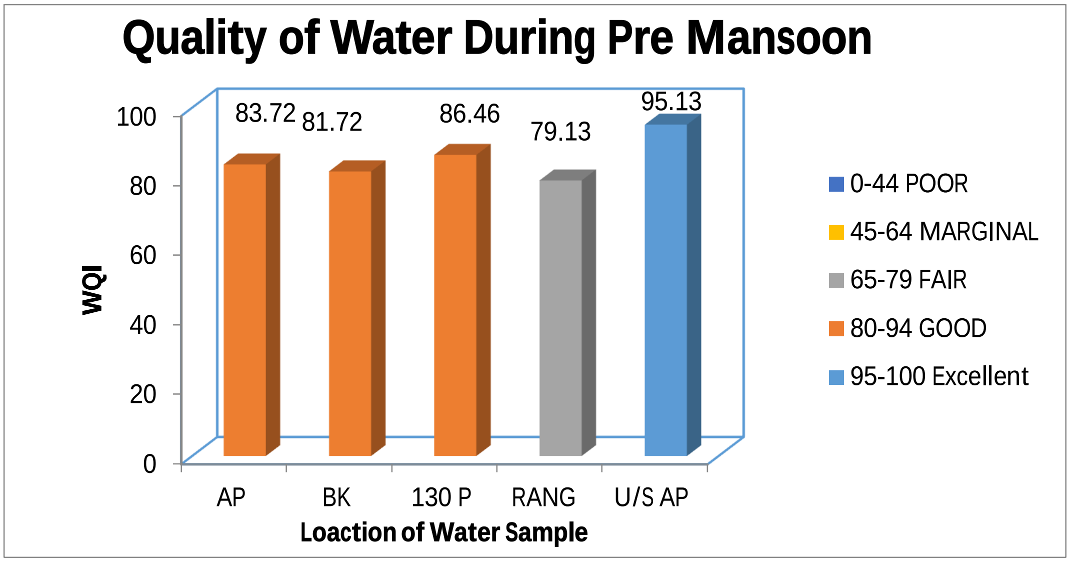

Figure 5: WQI During Pre Monsoon V/S Location of Water Sample

2) Water Quality Index during Monsoon

Different water quality levels are indicated by the CCME Water Quality Index (CCMEWQI) values for five different locations. Locations AP (Akhelgarh Plant) (85.82), RANG (Rangpur) (83.99), and U/S AP (upstream akhelgarh Plant) (87.63) are classified as Good (80-94), indicating that the water is generally safe for most applications, with moderate anthropogenic influences and little pollution. The Fair category (65-79) is occupied by locations BK (bhitriya kund) (77.42) and 130 P (130 mld plant) (70.87), which indicate moderate pollution levels that may impact sensitive aquatic species and may need remediation prior to specific usage. Localized sources of pollution are highlighted by the inclusion of two sites in the Fair category; they could be brought on by agricultural discharge, urban runoff, or inadequate wastewater management.

The pattern indicates comparatively higher water quality at AP and RANG, U/S AP indicating either less contamination or efficient natural self-purification. Water quality must be improved, particularly at BK (Bhitriya Kund) and 130 P (130 MLD PLANT), through targeted pollution control measures and ongoing monitoring in order to maintain ecological sustainability.

Table 7: CCME WQI value for Monsoon

CCMEWQI Value					
Rating of Water Quality	**AP**	BK	130 P	RANG	U/S AP
95-100 Excellent					
80-94 GOOD	85.82			83.99	87.63
65-79 FAIR		77.42	70.87		
45-64 MARGINAL					
0-44 POOR					

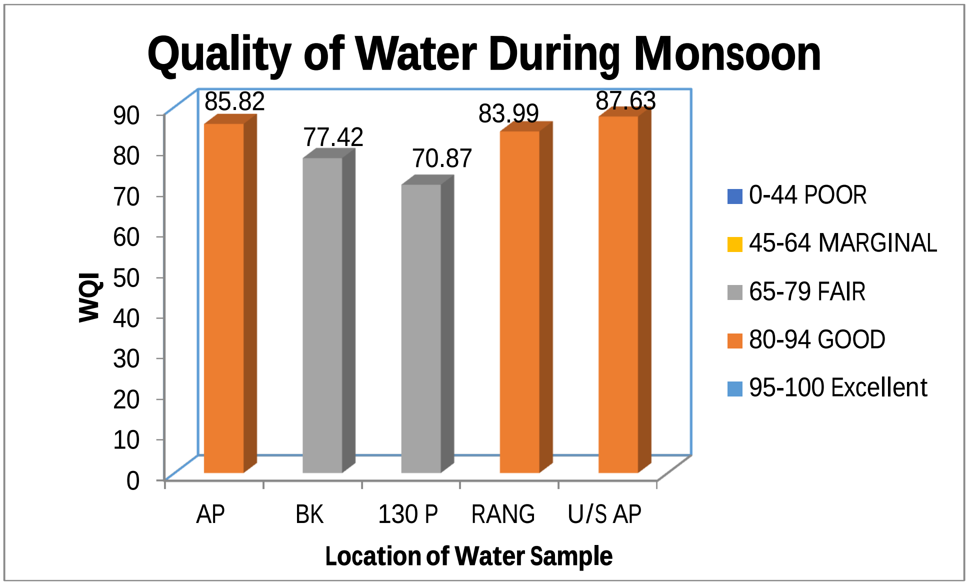

Figure 6: WQI During Monsoon v/s Location of Water Sample

3) Water Quality Index during Post-Monsoon

Diverse water quality conditions are shown by the CCME Water Quality Index (CCMEWQI) scores for five locations. Sites AP (Akhelgarh Plant), (82.83), 130 P (130 mld plant) (87.2), and U/S AP (Up Stream Akhelgarh Plant), (91.48) are classified as Good (80-94), indicating generally good water quality with just moderate anthropogenic influences that can be used for the majority of purposes with little remediation. On the other hand, sites BK (bhitriya kund) (79.03) and RANG(Rangpur) (78.13) are classified as Fair (65-79), meaning that they have moderate levels of pollution that could harm delicate aquatic life and need to be treated for certain purposes. Because there is less upstream pollution, the data indicates a positive trend at U/S AP (Upstream Akhelgarh), with the greatest quality. Localized contamination sources, most likely from industrial effluents, agricultural discharge, or urban runoff, are indicated by the somewhat lower values at BK (Bhitriya kund) and RANG (Rangpur).

This calls for targeted monitoring and pollution management in these locations. Although the majority of sites maintain high water quality overall, aggressive steps are necessary to stop further degradation, particularly at BK (Bhitriya kund) and RANG (Rangpur).

Table 8: CCME WQI value of Post Monsoon

CCMEWQI Value					
Rating of Water Quality	**AP**	BK	130 P	RANG	U/S AP
95-100 Excellent					
80-94 GOOD	82.83		87.2		91.48
65-79 FAIR		79.03		78.13	
45-64 MARGINAL					
0-44 POOR					

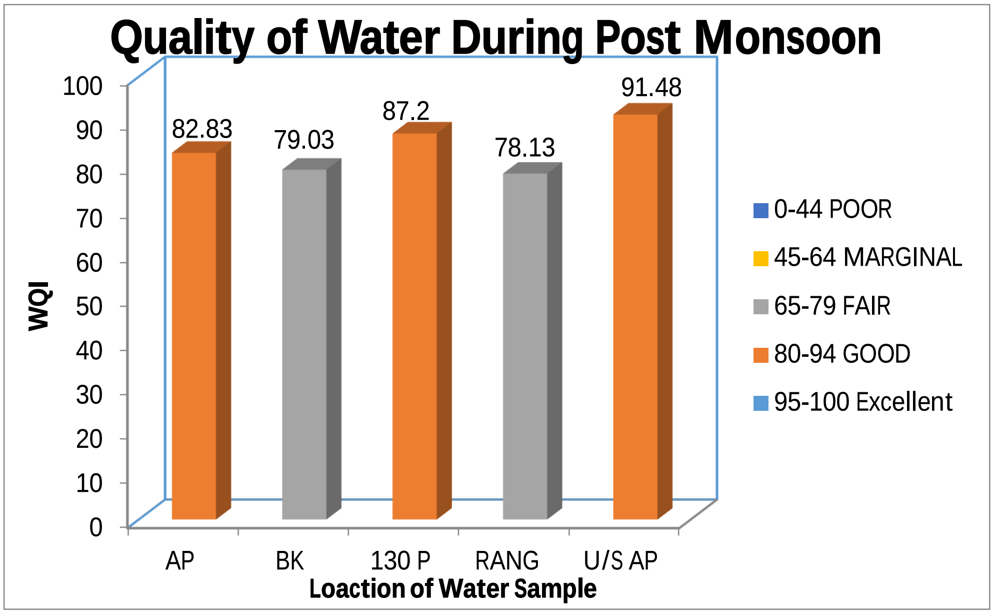

Figure 7: WQI during Monsoon v/s Location of Water Sample

V. CONCLUSION

The CCME Water Quality Index (CCMEWQI) analysis across Pre-Monsoon, Monsoon, and Post-Monsoon periods reveals an overall good water quality status at most sampling sites, especially at U/S AP (Upstream Akhelgarh Plant), which consistently recorded the highest values. However, sites like BK (Bhitriya Kund) and RANG (Rangpur) showed relatively lower scores, indicating moderate pollution levels. These variations suggest localized contamination, possibly from urban runoff or industrial discharges. While the water remains generally suitable for ecological and human use, continuous monitoring and targeted pollution control measures are essential to ensure long-term water sustainability and prevent further degradation in vulnerable areas.

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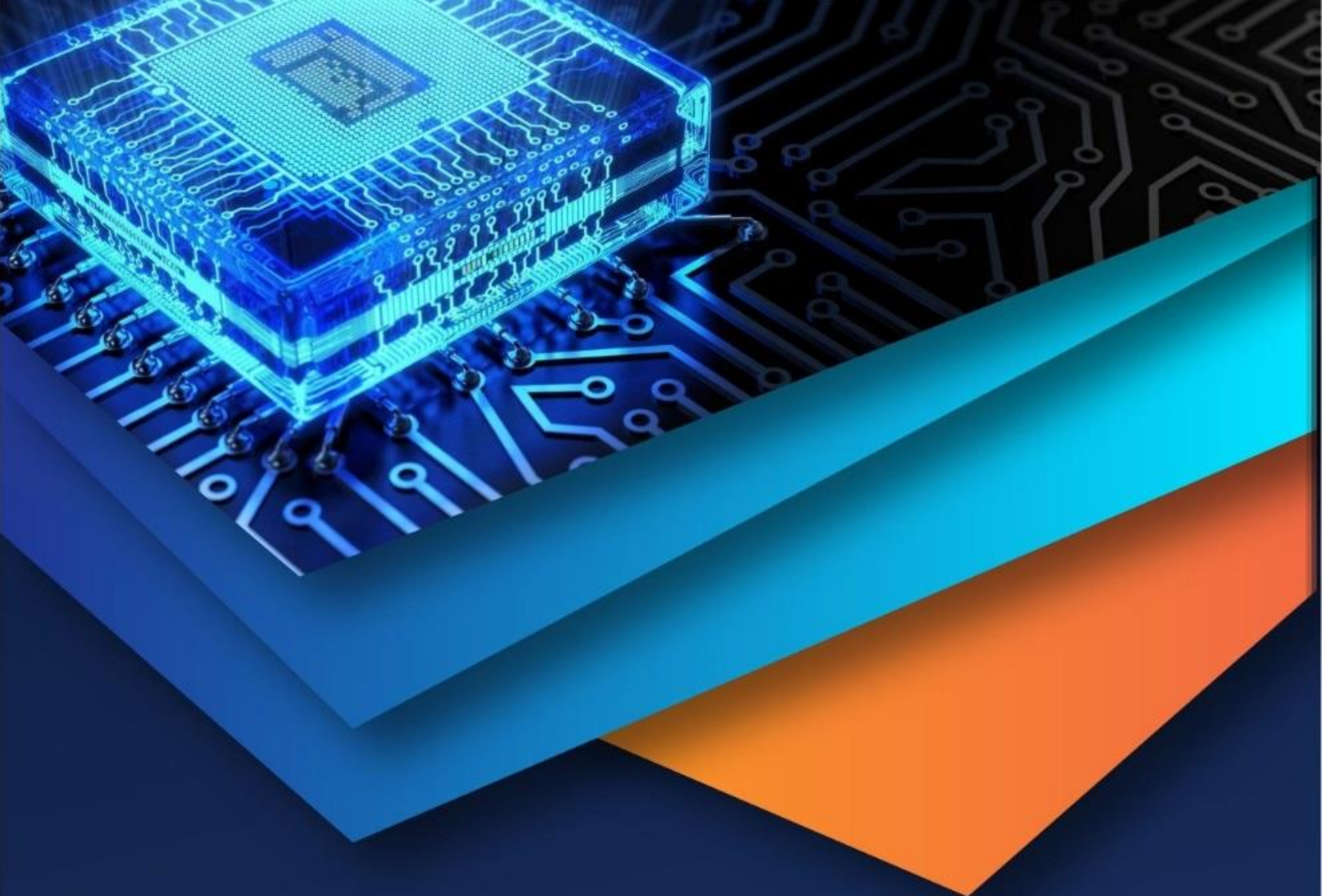

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