Assessment of Ground Water Quality Using Water Quality Index (WQI) in Puruliya District, West Bengal, India

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Abstract

The assessment of water quality is essential for ensuring safe and sustainable water resources, particularly in regions with diverse hydrological and land use patterns. This study evaluates the Ground water quality of Puruliya district, West Bengal, using the Water Quality Index (WQI) integrated with geospatial techniques. Water samples were collected from various locations and analyzed based on key physical-chemical parameters. The WQI values were computed to classify water into categories ranging from excellent to poor. GIS mapping was employed to visualize spatial variations in water quality across the district. The results indicate that while several areas fall under the 'excellent' and 'good' categories, certain pockets exhibit relatively lower water quality, possibly due to anthropogenic pressures and seasonal influences. The integration of WQI and GIS provides an effective framework for identifying pollution hotspots and guiding water resource management strategies in the region. This approach can be replicated for similar environmental assessments in other districts.

Keywords- Groundwater Quality, Water Quality Index (WQI), Puruliya District, WestBengal, Geographic Information System (GIS), Physico-chemical Parameters, Water Pollution, Rural Water Resources, Public Health Risk.

Introduction

Water is one of the most vital natural resources, playing a critical role in sustaining life, ecosystems, and socio-economic development. However, with growing population pressure, rapid urbanization, and industrial activities, ground water resources are increasingly being subjected to degradation in quality. Monitoring and assessing water quality has, therefore, become essential to ensure the sustainability of freshwater resources, particularly in rural and semi-urban districts like Puruliya in West Bengal, India.

The Water Quality Index (WQI) is a widely used tool to evaluate the overall quality of water by integrating various physical-chemical parameters into a single value that can be easily interpreted by policymakers, planners, and the public. WQI provides a holistic view of water health and helps categorize water bodies into 'excellent,' 'good,' 'poor,' or 'unfit' for use. When combined with geospatial technologies such as Geographic Information Systems (GIS), WQI mapping becomes a powerful tool to visualize spatial variations in water quality and identify critical zones that require attention.

Puruliya, located in the western part of West Bengal, is a region characterized by a hilly terrain, forest cover, and tribal population. Despite having natural streams and rivers, water accessibility and quality remain a challenge due to seasonal fluctuations, lack of treatment infrastructure, and localized pollution sources. Therefore, a comprehensive analysis of ground water quality in this region is essential.

This study aims to assess the ground water quality of Puruliya using the WQI method and visualize its spatial distribution through GIS mapping. By identifying patterns and pollution-prone zones, the research provides a scientific basis for local water resource planning, pollution control measures, and sustainable development efforts. The integration of field sampling, statistical analysis, and geospatial visualization in this study offers a robust framework for environmental monitoring and policy-making.

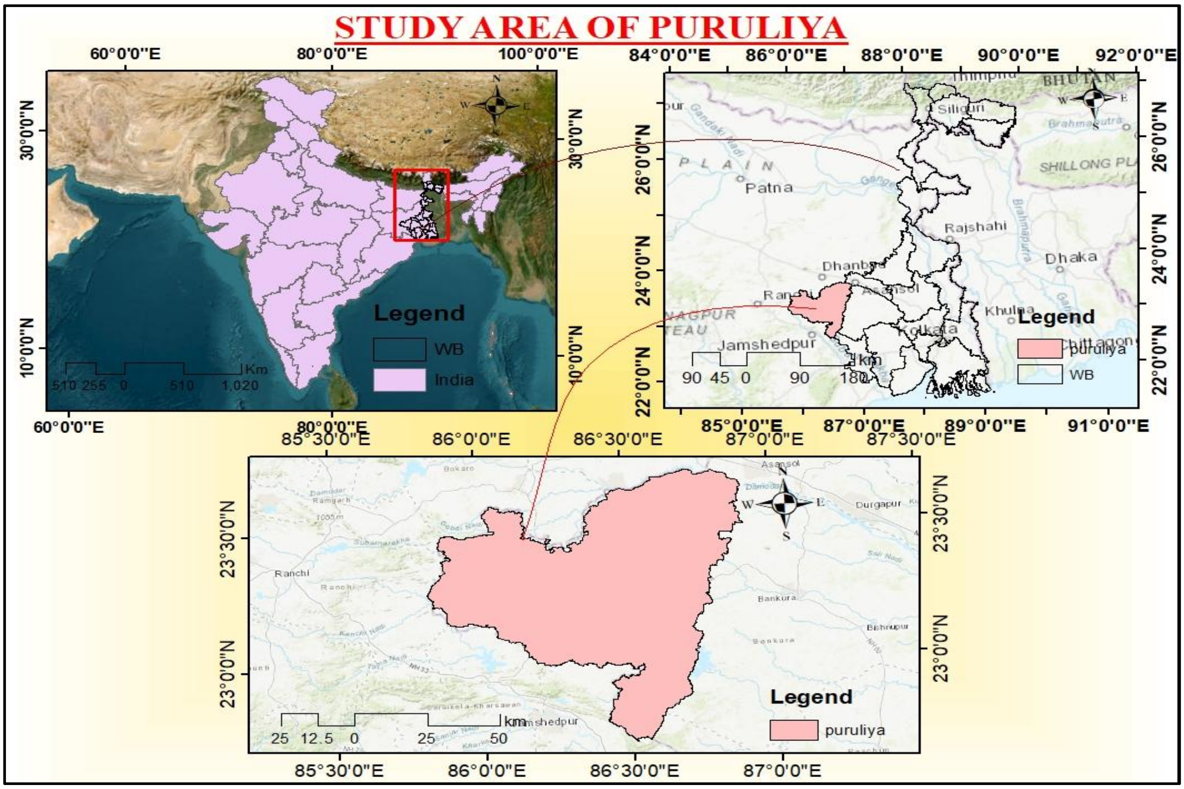
STUDY AREA

Puruliya district is located in the western part of West Bengal, India, between latitudes 22°42′ N to 23°42′ N and longitudes 85°49′ E to 86°54′ E. Covering an area of approximately 6,259 km², it forms part of the Chota Nagpur Plateau and is characterized by rugged topography, undulating terrain, scattered hills, and forested regions. The district shares its borders with Jharkhand to the west and south, and with the districts of Bankura, Paschim Medinipur and Bardhaman in West Bengal.

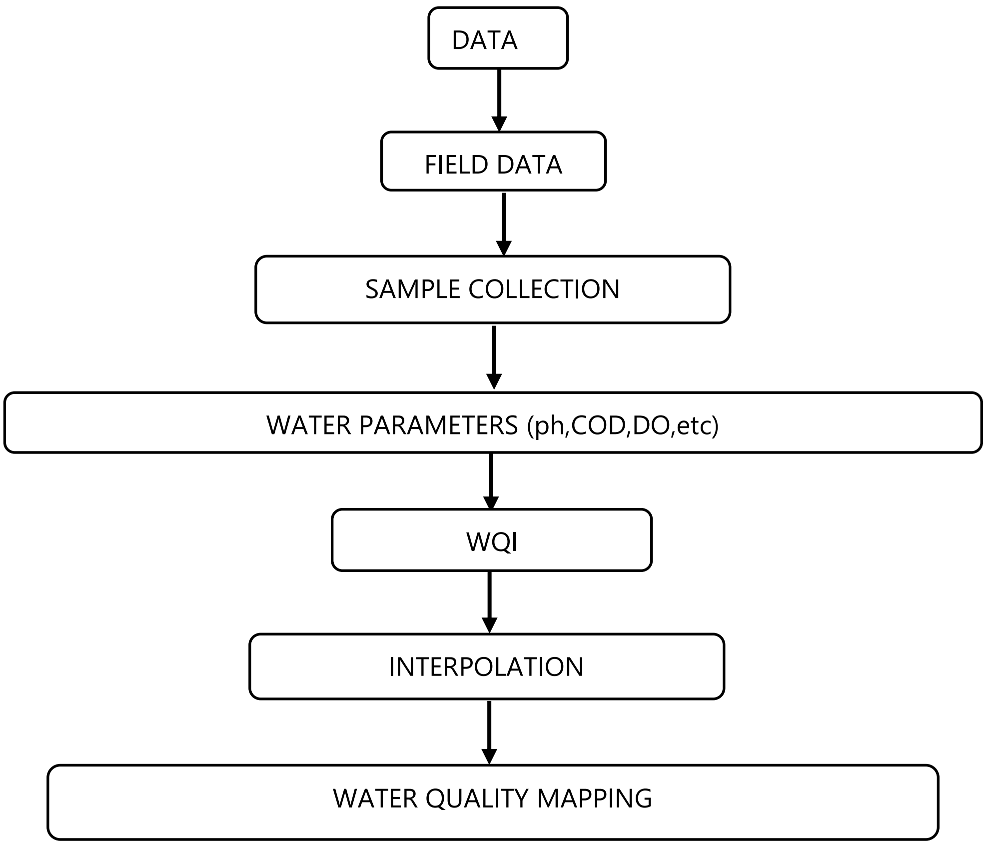
The region experiences a tropical climate with hot summers, moderate rainfall during the monsoon, and mild winters. The annual average rainfall ranges from 1100 mm to 1500 mm, predominantly received during the monsoon months (June to September). Rivers such as the Kangsabati, Subarnarekha, and Kumari, along with several seasonal streams and reservoirs, constitute the main surface water sources in the district.

Agriculture is the primary occupation in Puruliya, supported by surface water and limited groundwater resources. However, industrial activities, increasing population, and limited infrastructure for water treatment have led to growing concerns over the quality of water sources in the region. Additionally, the seasonal flow of streams and dependence on rain-fed systems make the district vulnerable to water scarcity and quality issues, especially during the dry season.

The district's diverse hydro-ecological setting and dependence on natural water bodies make it a suitable region for evaluating water quality using spatial and statistical approaches. This study focuses on assessing the surface water quality of key rivers and streams across different blocks in Puruliya using WQI and GIS tools.



METHODOLOGY



ANALYSIS AND RESULT:

In this study involves a systematic approach combining field sampling, laboratory analysis, Water Quality Index (WQI) computation, and geospatial mapping to assess the ground water quality in Puruliya district.

1. Sample Collection and Location Selection

Water samples were collected from multiple predetermined locations across the Puruliya district, including streams, rivers, and reservoirs. Sampling sites were chosen based on stream order, human settlements, land use patterns, and accessibility. The spatial distribution of sampling points was mapped using GPS coordinates and integrated into a GIS environment for further analysis.

Water Quality Parameters-

1. pH
2. Electric Conductivity
3. Total Dissolved Solids
4. Total Alkalinity
5. Chlorides
6. Total Hardness
7. Dissolved Oxygen
8. Fluoride
9. Calcium
10. Magnesium
11. Sulphate
12. Nitrate

Selection of WQI Method:

Weighted Arithmetic Index method (Brown et al., 1972)

SN	Parameters	Standard Permissible Value (Sn)	Recommended Agency
1	PH	8.5	ICMR/IBS
2	EC (µ-s/cm)	300	ICMR
3	TDS (mg/L)	500	ICMR / IBS
4	bicarbonate (mg/L)	120	ICMR
5	Chlorides (mg/L)	250	ICMR
6	Total Hardness (mg/L)	300	ICMR / IBS
7	DO (mg/L)	5	ICMR / IBS
8	Fluoride (mg/L)	1.5	IBS
9	Ca (mg/L)	75	ICMR / IBS
10	Mg (mg/L)	30	ICMR / IBS
11	Sulphate (mg/L)	200	ICMR / IBS
12	Sodium (mg/L)	200	ICMR/ IBS
13	Potassium (mg/L)	12	ICMR/ IBS

The Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI),National Sanitation Foundation Water Quality Index (NSF WQI) and many more.

Selected parameters must have standard limit prescribed by WHO/BIS/ICMR Calculation of parameters must have standard limit prescribed by WHO/BIS/ICMR. Calculation of unit weight (Wn) for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters. Wn = K/Sn

Where,

Wn = unit weight of nth parameters

Sn = standard value for nth parameters

$K= \frac{1}{\frac{1}{S1}+\frac{1}{S2}+\frac{1}{S3}+\dots\dots\dots+\frac{1}{Sn}} = \frac{1}{\sum\frac{1}{Sn}}$ (constant for proportionality and is given as (Kalavathy et al., 2011)

Table 2 : calculation table of unit weight (Wn)

SN	Parameters	Standard Permissible Value (Sn)	1/Sn	∑1/Sn	k=1/∑1/Sn	Wn= k/Sn
1	**Potassium (mg/L)**	12	0.083333	0.931647	1.073368	0.089447
2	**Chloride (mg/L)**	250	0.004	0.931647	1.073368	0.004293
3	**Calcium (mg/L)**	75	0.013333	0.931647	1.073368	0.014312
4	**Bicarbonate (mg/L)**	200	0.005	0.931647	1.073368	0.005367
5	**Magnesium (mg/L)**	30	0.033333	0.931647	1.073368	0.035779
6	**Fluoride (mg/L)**	1.5	0.666667	0.931647	1.073368	0.715579
7	**Electrical Conductivity (μS/cm) at 25°C)**	300	0.003333	0.931647	1.073368	0.003578
8	**Sodium (mg/L)**	200	0.005	0.931647	1.073368	0.005367
9	**pH**	8.5	0.117647	0.931647	1.073368	0.126279
			∑1/Sn=0.931647			**∑Wn** =1

Ideal value

All the ideal values (Vio) are taken as zero for drinking water except for pH=7.0, Dissolved Oxygen = 14.6 mg/L,

And Fluoride = 1 mg/L.

Calculation of Sub Index of Quality Rating (Qn)

Let there be n water quality parameters where the quality rating or sub index (Qn) corresponding to the nth parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value. The value of qn is calculated using the following expression

Formula:

Qn = 100[(Vn-Vio)/(Sn-Vio)]

Where,

Qn = quality rating for the nth water quality parameter.

Vn = observed value of the nth parameter.

Sn = standard permissible value of nth parameter.

Vio = ideal value of nth parameter in pure water.

All the ideal values (Vio) are taken as zero for drinking water except for pH=7.0, Dissolved Oxygen = 14.6 mg/L, and Fluoride = 1 mg/L.

Calculation of Quality Rating for Ph:

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following relation:

QpH = 100[(VpH-7.0)/(8.5-7.0)]

Where,

VpH = observed value of pH during the study period.

Calculation of Quality Rating for Dissolved Oxygen:

The ideal value (Vio) for dissolved oxygen is 14.6 mg/L and standard permitted value for drinking water is 5mg/L. Therefore, quality rating is calculated from following relation:

QDO = 100[(VDO - 14.6)/(5 - 14.6)]

Where,

VDO = observed value of dissolved oxygen

Calculation of Quality Rating for Fluoride:

The ideal value (Vio) for fluoride is 1 mg/L and standard permitted value for drinking water is 1.5 mg/L. Therefore, quality rating is calculated from following relation:

QF = 100[(VF - 1)/(1.5 - 1)]

where,

VF = observed value of fluoride.

Calculation of WQI :

WQI is calculated from the following equation

WQI = ∑ QnWn / ∑Wn

Table-3 shows the classification of water quality status based on Water Quality index (Ramakrishnaiah et al. 2009, Bhaven et al. 2011 and Srinivasa Kushtagi et. al. 2012,).

Table 3: Water Quality Classification Based on WQI Value

Class	WQI value	Water Quality Status
1	<50	Excellent
2	50-100	Good Water
3	100-200	Poor water
4	200-300	Very poor water
5	>300	Water unsuitable for drinking

Station Name	Potassium (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Bicarbonate (mg/L)	Magnesium (mg/L)	Fluoride (mg/L)	Electrical Conductivity (µS/cm) at 25°C)	Sodium (mg/L)	pH
Anara	1.85	109.895	10	207.4	49.815	0.08	820	76.14	7.83
Arsha	15.98	77.99	16	219.6	36.45	0.31	576	43.28	8.07
Baghmundi	27.85	265.875	22	213.5	99.63	0.28	1386	88.65	7.85
Balitora	2.58	141.8	16	183	63.18	0.86	937	78.64	7.6
Bamundiha	1.64	49.63	22	115.9	12.15	0.08	311	28.96	7.84

Barabazar	65.06	311.96	58	402.6	95.985	0.34	1728	105.68	8.08
Bero	2.44	46.085	12	146.4	20.655	0.06	435	53.99	7.98
Bishpuria	2.13	265.875	16	170.8	108.135	0.19	1047	42.22	7.82
Chakaltore	1.81	81.535	16	152.5	40.095	0.68	542	35.74	7.98
Deuli	1.47	138.255	18	183	71.685	0.19	800	41.82	8.09
Dhabani	9.45	99.26	8	207.4	69.255	0.27	709	23.91	8.08
Dhobakata	3.11	191.43	30	280.6	61.965	0.38	1168	112	8.15
Durgu	4.52	280.055	14	134.2	98.415	0.16	1153	67.14	7.94
Duriakata	1.19	35.45	36	201.3	17.01	0.24	414	28.64	8.15
Gobag	36.35	85.08	22	115.9	21.87	0.17	645	50.3	7.81
Hansla More	1.78	21.27	14	128.1	17.01	0.64	260	12.03	8
Imundi	38.4	347.41	14	298.9	98.415	0.13	1560	132.7	7.95
Indrabil	7.22	145.345	20	573.4	115.425	0.16	1325	87.78	8.23
Kantadihi	7.63	556.565	60	213.5	173.745	0.1	1984	93.71	7.89
Kashiberia	11.44	173.705	66	353.8	68.04	0.41	1410	114.34	8.32
Keshargarh	14.93	251.695	14	359.9	120.285	0.16	1430	88.32	8.24
Khariduyara	2.82	124.075	16	256.2	49.815	0.36	758	71.78	8.2
Korenge	1.75	17.725	16	128.1	15.795	1.17	250	10.88	7.81
Kotshila	3.68	173.705	10	115.9	64.395	0.23	838	66.99	7.69
Kulabahal	38.7	138.255	22	195.2	40.095	0.26	967	85.32	8.13
Kulgara	0.95	10.635	14	79.3	4.86	0.18	155	12.82	7.77
Kustar	7.91	63.81	14	323.3	52.245	0.08	685	53.23	8.3
Manbazar	1.02	102.805	14	219.6	23.085	0.24	694	90.58	8.05
Namsole	1.56	28.36	24	122	13.365	0.37	286	14.98	7.94
Napara	12.88	113.44	14	195.2	63.18	0.12	863	49.47	7.74
Nituria	2.91	53.175	20	201.3	42.525	0.37	623	41.26	7.98
Pandrama	3.51	166.615	18	115.9	68.04	0.23	820	46.71	7.9
Podalaroad	8.02	414.765	70	201.3	134.865	0.73	2108	120.94	7.81
Sankhari	7.5	42.54	32.064	305.05	17.024	1.1	605	77	7.82
Santuri	4.08	56.72	22	115.9	26.73	0.24	375	14.52	7.9
Sindurpur	31.29	113.44	30	213.5	52.245	0.52	958	62.98	8.35
Takariya	15.05	95.715	12	164.7	41.31	0.64	701	62.44	7.86
Tulin	8.46	304.87	16	128.1	74.115	0.24	1221	122.41	7.88

Table 4: Calculation of Water Quality Index

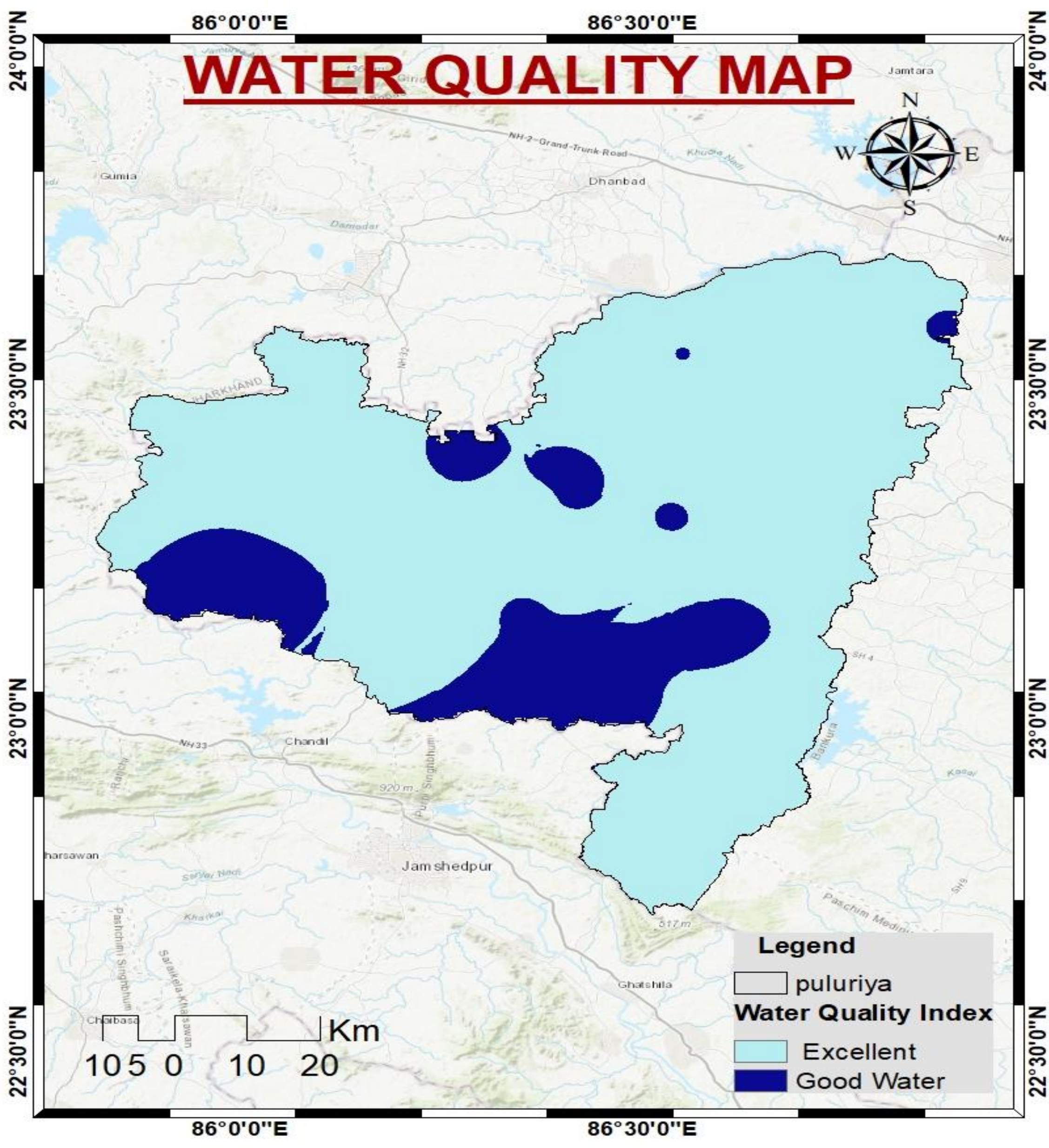
Anara station										
Sl no.	**Parameters**	Standard Permissible Value (Sn)	1/Sn	∑1/Sn	k=1/∑1/Sn	Wn= k/Sn	Observed value(Vn)	IDEAL VALUE	qn	wn*qn
1	**Potassium (mg/L)**	12	0.083333	0.931647	1.073368	0.089447	1.85	0	15.41666667	1.37898
2	**Chloride (mg/L)**	250	0.004	0.931647	1.073368	0.004293	109.895	0	43.958	0.188732
3	**Calcium (mg/L)**	75	0.013333	0.931647	1.073368	0.014312	10	0	13.33333333	0.190821
Sl no.	**Parameters**	Standard Permissible Value (Sn)	1/Sn	∑1/Sn	k=1/∑1/Sn	Wn= k/Sn	Observed value(Vn)	IDEAL VALUE	qn	wn*qn

4	**Bicarbonate (mg/L)**	200	0.005	0.931647	1.073368	0.005367	207.4	0	103.7	0.556541
5	**Magnesium (mg/L)**	30	0.033333	0.931647	1.073368	0.035779	49.815	0	166.05	5.941091
6	**Fluoride (mg/L)**	1.5	0.666667	0.931647	1.073368	0.715579	0.08	0	5.333333333	3.816419
7	**Electrical Conductivity (μS/cm) at 25°C)**	300	0.003333	0.931647	1.073368	0.003578	820	0	273.3333333	0.977957
8	**Sodium (mg/L)**	200	0.005	0.931647	1.073368	0.005367	76.14	0	38.07	0.204316
9	**pH**	8.5	0.117647	0.931647	1.073368	0.126279	7.83	7	55.33333333	6.987414
			0.931647			1				20.24227
	Water Quality Index = ∑ WnQn/∑Wn = 20.24227									

Table 5: Station wise Water Quality rating

Station Name	Longitude	Latitude	WQI
Anara	86.58	23.49	20.24227
Arsha	86.1625	23.33333	41.88666
Baghmundi	86.05	23.19167	56.49487
Balitora	86.875	23.58	57.90423
Bamundiha	86.3536	23.2386	14.82418
Barabazar	86.375	23.0041	90.32197
Bero	86.7625	23.50833	16.75931
Bishpuria	86.7375	23.2583	33.03366
Chakaltore	86.3625	232166	48.41765
Deuli	86.475	23.5375	30.02365
Dhabani	86.49	22.9	39.06542
Dhobakata	86.377	23.333	40.86539
Durgu	86.013	23.385	33.31625
Duriakata	86.689	23.298	25.90491
Gobag	86.775	23.6	46.41345
Hansla More	86.1717	23.3272	43.29518
Imundi	86.2753	23.3936	58.4422
Indrabil	86.7825	23.4113	41.12109
Kantadihi	86.308	23.1958	43.96309
Kashiberia	86.549	23.544	51.8092
Keshargarh	86.5625	23.254	47.1538
Khariduyara	86.63	22.9892	37.6218
Korenge	85.975	23.21667	66.82923
Kotshila	86.00833	23.45	29.18335
Kulabahal	86.542	23.303	58.10823
Kulgara	86.58	23.32	17.07445
Kustar	86.516	23.504	29.09161

Manbazar	86.654	23.06	25.90598
Namsole	86.246	23.131	29.5365
Napara	86.675	23.4	31.23786
Nituria	86.824	23.662	35.00876
Pandrama	86.3228	23.2664	31.32384
Podalaroad	86.4	23.35	69.13318
Sankhari	86.359	23.053	69.43143
Santuri	86.857	23.525	26.56951
Sindurpur	86.61	23.122	68.37782
Takariya	86.348	23.159	55.75518
Tulin	85.89444	23.35389	36.96014

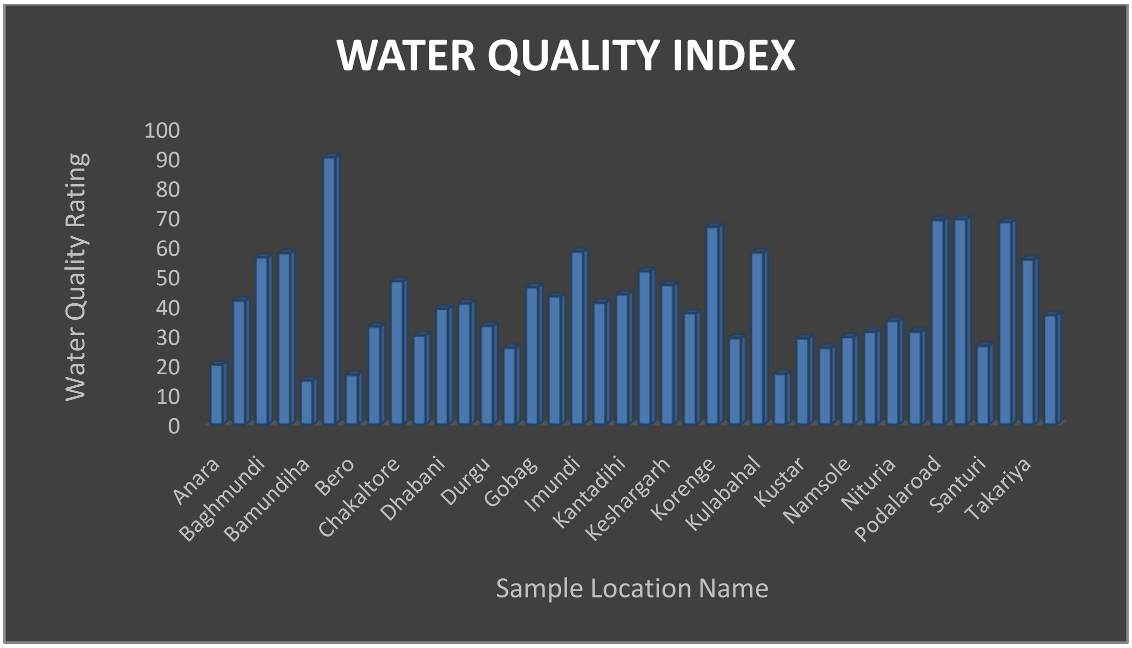


CONCLUSION

This study successfully assessed the ground water quality of Puruliya district, West Bengal, using the Water Quality Index (WQI) approach integrated with Geographic Information System (GIS) techniques. The analysis of physics-chemical parameters across various sampling sites revealed that most locations fall under the 'Excellent' and 'Good' categories, indicating overall favorable water conditions. However, certain pockets with 'Moderate' and 'Poor' WQI scores highlight emerging concerns due to anthropogenic activities, agricultural runoff, and inadequate sanitation.

The spatial distribution of WQI, visualized through GIS-based mapping, provided a clear understanding of pollution patterns and water quality gradients across different stream orders. This geospatial insight is valuable for identifying critical zones that require immediate intervention and sustainable management.

The study emphasizes the need for regular water quality monitoring, especially in ecologically sensitive and densely populated regions. By integrating scientific analysis with spatial tools, the research offers a replicable framework for water quality assessment and policy planning in similar geographic settings across India.



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