JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ASSESSMENT OF THE GROUNDWATER QUALITY IN PARTS OF THE GANDAK RIVER BASIN, BIHAR

Prahlad Kumar Arya* and Anil Kumar

Department of Geology, Patna Science College, Patna University, Patna 800005

Abstract: The Gandak River basin in Bihar is home to millions of people who heavily depend on groundwater for various purposes. As intensive agricultural activities have expanded, urbanization has increased, and demands for domestic uses have grown, both the groundwater quality and quantity degraded rapidly. Geologically, the study area is composed of older and newer alluvium ranging in age from middle Pleistocene time to recent. The present study focuses on the assessment of groundwater quality in the parts of the Gandak River basin. A total of 25 groundwater samples were collected during the pre-monsoon season (May 2022) and post-monsoon season (November, 2021) along the Gandak river flow alignment. The samples have been analyzed for determining the physical and chemical parameters of water quality such as temperature, pH, electric conductivity (EC), Total dissolved solids (TDS) and important ions concentrations of water quality using the 23rd edition of American Public Health Association Standards. The outcome of the analysis was classified as per BIS (2012) and the WHO (2011) standards for knowing the suitability of water for drinking purposes. In most cases, groundwater samples in the study area of the Gandak River basin are found mildly alkaline, with pH ranging from 7.57 to 8.25. In the analysis, it has been found that all the groundwater samples fall under the permissible or acceptable limits set by BIS and WHO. Therefore, the hydrochemical analysis indicates that the groundwater quality in the study area is mostly suitable for drinking and domestic uses.

Keywords: Hydrochemical analysis, Groundwater quality assessment, Domestic uses.

Introduction:

Groundwater is one of the most precious natural resources on the Earth. The groundwater is being utilized for drinking, irrigation, and industrial purposes. India extracts huge amounts of groundwater for the above-mentioned purposes. Groundwater was instrumental in spurring India's Green Revolution and in making it a food secured country, but its extraction has resulted in its alarming decline. Apart from quantity, groundwater quality is another important concern in today's world as it affects public health. The quality of groundwater has changed to the extent that the use of such water could be hazardous. Groundwater quality problems are primarily caused by geologic and man-made contamination.

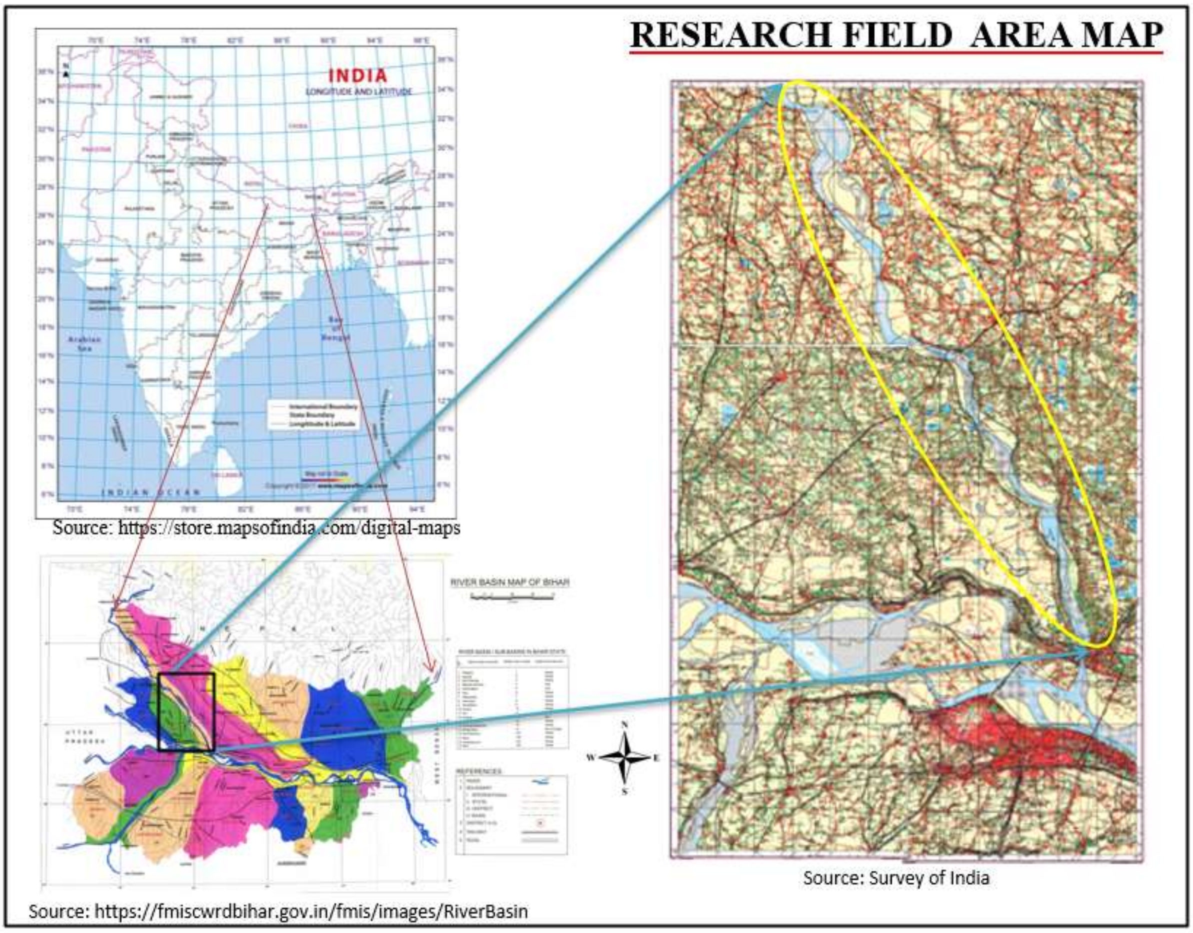
In Bihar, there have been a considerable number of reports of contaminated groundwater. The first scientific report on the groundwater resources of Bihar was given in 1968 (Roy & Sinha, 2007).

Several river streams make up the Indo-Gangetic Basin (IGB), which is a significant source of freshwater resources for the Indian subcontinent. The Gandak River Basin, or GRB, has a distinct topography made up of mountains, glaciers, and snowfields over Nepal, with an alluvial plain forming in India downstream. Understanding the hydrological reactions and high precipitation occurrences of GRB is frequently challenging because of the intricate character of the mountainous habitat. The mid-Ganga region, specifically the lower portion of the Gandak catchment overlying the IGB aquifer in India, is an area that has not received much attention to date. This area is the focus of the present study. According to reports, the final 43 km of the river has slightly worse water quality than the upland portion. The river water's pH readings ranged from neutral to slightly alkaline. In the lower river segment, there were no appreciable differences in conductivity, total dissolved solids, total hardness, chloride, phosphate, or nitrate. The river water appeared to be somewhat hard based on the hardness ratings. The final 23 km of the river segment appears to have seen an increase in turbidity readings. The final 43 km of the river's water had a higher chemical oxygen requirement than the upland portion. According to the Water Quality Index, which takes into account a variety of physico-chemical factors, the water from all sampling locations fell into the poor and extremely bad category, making it unfit for human consumption (Kumar and Choudhary, 2016).

The present study is aimed at evaluating the overall groundwater quality in parts of the Gandak River basin in Bihar. Furthermore, the study is aimed to determine whether hydrogeological factors or human influences affect the physical and chemical composition of groundwater in the study area of the Gandak River basin of Bihar.

Study Area:

The study area includes the districts of Vaishali, Muzaffarpur and Saran of Bihar (fig. 1) along the flow alignment of the Gandak River. A groundwater sampling has been conducted in the districts of Vaishali and Muzaffarpur on the east side of the Gandak River, as well as the Saran districts of Bihar on the west side of the Gandak River. In total, 25 groundwater samples were collected in the research field during all these visits (table 1). Temperature, pH, and TDS were recorded on-site using portable digital meters during groundwater sampling. We conducted a post-monsoon groundwater sampling in November 2021, and a pre-monsoon groundwater sampling in May 2022.



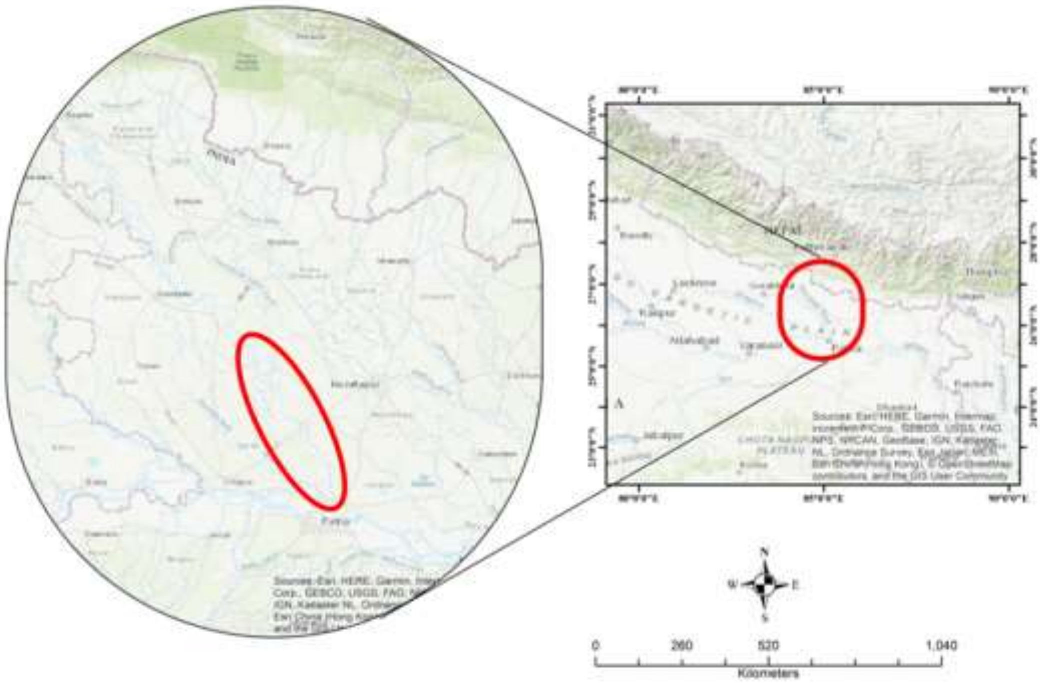


Fig. 1. Study area map in the parts of the Gandak River basin, Bihar

Sample No.	Sample Location	District	Block	Latitude	Longitude
GW1	Adalpur	Vaishali	Hajipur	25°.70 086 N	85°.20 578 E
GW2	Chak Aima	Vaishali	Hajipur	25.734644 N	85.202609 E
GW3	Manua	Vaishali	Hajipur	25.755954 N	85.195076 E
GW4	Daulatpur Chandi	Vaishali	Hajipur	25.788079 N	85.188747 E
GW5	Basanta Jahanabad	Vaishali	Lalganj	25.832613 N	85.180948 E
GW6	Manpur Motaluke Ghatarodih	Vaishali	Lalganj	25.870545 N	85.181691 E
GW7	Shahdullahpur	Vaishali	Lalganj	25.903814 N	85.145472 E

GW8	Ibrahimpur	Vaishali	Vaishali	25.939936 N	85.122027 E
GW9	Musud Chak Nawada	Vaishali	Vaishali	25.960021 N	85.107377 E
GW10	Nandlalpur, Langari Pakar	Vaishali	Vaishali	25.991437 N	85.081631 E
GW11	Rewa Basantpur North,	Muzaffarpur	Saraiya	26.021225 N	85.065702 E
GW12	Gaddopur	Muzaffarpur	Paroo	26.055504 N	85.037233 E
GW13	Chak Bharath Patti	Muzaffarpur	Paroo	26.0926 N	85.012871 E
GW14	Neknamepur	Muzaffarpur	Paroo	26.129378 N	84.993311 E
GW15	Bindi urf Ibrahimpur	Muzaffarpur	Paroo	26.170214 N	84.974501 E
GW16	Hussepur	Muzaffarpur	Sahebganj	26.196806 N	84.950257 E
GW17	Manaen	Muzaffarpur	Sahebganj	26.223206 N	84.946206 E
GW18	Bangra Nizamat	Muzaffarpur	Sahebganj	26.241324 N	84.92367 E
GW19	Madhopur Hajari	Muzaffarpur	Sahebganj	26.264476 N	84.898045 E
GW20	Chakiya	Saran	Panapur	26.213069 N	84.873113 E
GW21	Dubauli	Saran	Panapur	26.172757 N	84.865044 E
GW22	Turki, Mahmadpur	Saran	Panapur	26.134326 N	84.85471 E

GW23	Pokhrerha	Saran	Taraiya	26.091706 N	84.872352 E
GW24	Taraiya	Saran	Taraiya	26.066239 N	84.885772 E
GW25	Pachraur	Saran	Taraiya	26.02542 N	84.906094 E

Materials and methods:

Water samples collected from the study area were analyzed in the geochemical laboratory. The American Public Health Association, (2017) 23rd Edition, Standard Methods for the Examination of Water and Wastewater, were strictly followed while conducting the chemical analysis of groundwater samples. A description of the instruments used and the methods followed during the hydrochemical analysis of the samples is presented in Table 2.

Table 2: Methods or Instruments used in the analysis of physicochemical parameters

SI. No.	Parameters	Name of the Instruments Used
1.	pH	Hand Held Digital meter, Hanna H198107
2.	Total Dissolved Solid (TDS)	TDS-3, HM Digital TDS Meter.
3.	Electrical Conductivity (EC)	Euthech PC 700 Multiparameter meter
4.	Sodium (Na^+)	Microcontroller Flame Photometer, VSI-604:
5.	Potassium (K^+)	Microcontroller Flame Photometer, VSI-604
6.	Calcium (Ca^{2+})	EDTA Titrimetric Method
7.	Magnesium (Mg^{2+})	EDTA Titrimetric Method
8.	Total Hardness	EDTA Titrimetric Method
9.	Carbonate and Bicarbonate (HCO_3^-)	Acid Titration Method
10.	Sulphate (SO_4^{2-})	Microprocessor Single Beam UV-VIS Spectrophotometer LI-285
11.	Chloride (Cl^-)	Mohr's Titrimetric Method

Results and discussion:

There is no doubt that groundwater is one of the most important natural resources for human and animal life. The various characteristics of groundwater samples from parts of the Gandak River basin, Bihar have been analyzed to determine their suitability for drinking, irrigation, industrial, and other uses. Physio- chemical parameters of the groundwater samples were analyzed in both pre and post monsoon seasons (table 3 and 4). Hydrochemical analysis of samples collected from the study area during the pre- and post-monsoon seasons has shown that the groundwater fall in hard to extremely hard category.

Table 3: PHYSIOCHEMICAL DATA OF POST-MONSOON PERIOD GROUNDWATER SAMPLES

Sample No.	Temperature (T) °C	pH	Total Dissolved Solids (TDS) (mg/l)	Electrical Conductivity (µS/cm)	Ca^{2-} (mg/l)	Mg^{2-} (mg/l)	Na^{+} (ppm)	K^{+} (ppm)	SO_4 (mg/l)	Cl^{-} (mg/l)	HCO_3^{-} (mg/l)	Total Hardness (mg/l)
GW1	24.7	7.84	336	668	73.75	34.99	29.5	4.2	86.97	42.6	320	344
GW2	24.9	8.15	310	619	84.51	3.89	64.4	1.3	58.48	36.92	280	264
GW3	24.4	8.06	309	617	88.10	28.67	46.46	1.9	75.11	14.2	380	302
GW4	25.4	7.71	284	568	73.75	48.84	25.4	3.3	66.16	48.28	340	337
GW5	24.6	7.84	236	471	64.30	34.75	24.2	2.6	33.48	28.4	320	283
GW6	24.5	7.96	239	478	59.32	36.69	43.47	1.6	60.11	39.76	360	271
GW7	24.6	7.98	267	534	82.91	18.23	39.7	2.6	26.86	31.24	340	295
GW8	24	7.76	224	447	70.92	14.58	44.62	5	53.13	39.76	320	308
GW9	24.3	7.79	198	396	117.75	15.07	72.5	6.3	101.51	45.44	400	294
GW10	24	7.92	279	557	102.91	12.88	23.3	2.5	37.32	56.8	320	245
GW11	25	7.91	231	462	79.70	21.87	68.8	0.8	25	45.44	380	278
GW12	25.4	7.79	227	454	68.94	7.29	53.59	26.8	82.56	19.88	320	274
GW13	24.4	7.69	426	848	61.68	15.55	103	1.8	46.2	79.52	360	244

GW14	24.4	7.57	581	1164	80.62	69.98	78.9	3.5	46.58	153.36	480	504
GW15	24.2	7.65	461	921	72.22	45.68	39.4	17.3	27.97	76.68	440	452
GW16	24	7.91	592	1184	92.14	48.60	34.7	4.5	94.08	65.32	400	432
GW17	24.9	7.77	298	597	51.54	29.16	36.6	4.1	42.15	14.2	360	348
GW18	25.1	7.84	287	575	94.13	67.07	24.7	2.4	94.56	93.72	360	524
GW19	25.1	7.88	326	650	78.94	60.26	39.3	9.3	61.01	55.38	440	480
GW20	24.9	7.57	462	924	67.03	41.80	58.2	3.2	67.68	65.32	420	420
GW21	24.8	7.89	358	716	82.52	30.62	35.6	5	36.83	25.56	440	286
GW22	24	8.27	333	666	124.97	23.33	35.9	3.6	67.2	36.92	420	288
GW23	24.4	7.77	222	444	72.91	23.33	32.2	4.1	18.1	66.74	300	304
GW24	24.6	7.73	315	628	83.37	35.48	33.8	12.2	15.31	66.03	380	322
GW25	24.6	7.79	319	637	90.16	34.51	16.8	3.2	76.32	34.08	380	338

Table 4: PHYSIOCHEMICAL DATA OF PRE-MONSOON PERIOD SAMPLES

Sample No.	Temperature (T) °C	pH	Total Dissolved Solids (TDS) (mg/l)	Electrical Conductivity (µS/cm)	Ca^{2-} (mg/l)	Mg^{2-} (mg/l)	Na^{+} (ppm)	K^{+} (ppm)	SO_4 (mg/l)	Cl^{-} (mg/l)	HCO_3^{-} (mg/l)	Total Hardness (mg/l)
GW1	25.6	7.97	268	534	64.13	61.24	29.2	1.5	34.18	151.12	220	412
GW2	25.8	7.86	560	1118	88.18	26.24	79.3	1.6	94.02	127.8	220	328
GW3	26.3	8.09	504	1007	64.13	44.71	81.4	5.7	97.7	142	320	344
GW4	26	7.98	415	830	56.11	57.83	33.5	6.5	87.13	110.76	220	378
GW5	25.9	8.21	246	491	40.08	53.22	34.1	2.1	34.84	67.04	340	319
GW6	26.4	8.26	294	587	48.10	54.43	48.9	2.4	39.84	108.4	280	344
GW7	25.4	8.38	280	560	72.14	43.74	51.6	2.6	18.36	94.2	310	360
GW8	25.6	8.05	280	560	104.21	29.89	36.9	4.2	36.39	101.4	340	383
GW9	25.9	8.13	299	597	96.19	14.09	40.2	3.7	70.57	124.2	320	298
GW10	24.9	8.14	207	413	60.92	44.71	22.2	3	28.44	104.2	240	336
GW11	24.9	8.25	233	466	59.32	35.48	25.7	1.9	30.33	84.2	300	294
GW12	26.2	8.07	649	1297	104.21	10.94	96.7	20.7	115.49	133.48	320	305
GW13	25.7	8.05	221	441	56.11	52.25	22.6	6.4	23.44	134.2	400	355
GW14	25	8.1	248	495	80.16	105.22	22.2	3.5	33.69	194.2	200	633
GW15	25	8.01	207	413	73.75	67.55	21.2	10.1	22.54	101.36	300	462

GW16	25.6	7.91	252	504	80.16	73.14	19.2	3.9	52.21	139.76	280	501
GW17	26.1	7.96	231	461	96.19	31.10	32.2	6.9	47.87	34.2	300	368
GW18	25.9	8.11	350	699	102.60	84.08	15.3	5	56.72	76.68	340	602
GW19	25.8	8.04	209	416	80.16	82.13	16.8	23.8	12.05	28.4	360	538
GW20	24.9	8	263	526	83.37	65.37	17.4	3.6	48.52	88.28	200	477
GW21	25.4	8.13	212	424	65.73	36.94	32.9	3.5	31.23	61.36	300	316
GW22	26.2	8.07	266	531	68.94	34.02	4.5	6.4	39.18	92.6	260	312
GW23	26.1	8.03	154	308	67.33	38.88	15.5	3.1	14.26	114.2	240	328
GW24	26.2	8.21	203	405	54.51	55.89	39.9	2.1	9.51	8.52	280	366
GW25	25.8	8.24	268	536	67.33	49.33	42.6	2.5	46.39	111.36	320	371

The samples have been analyzed for determining the physical and chemical parameters of water quality such as temperature, pH, electric conductivity (EC), Total dissolved solids (TDS) and ions concentrations using the 23rd edition of American Public Health Association Standards.

Electrical conductivity and total dissolved solids in the groundwater samples were found below acceptable or permissible levels as per the Bureau of Indian Standards (BIS). In most cases, groundwater samples are found mildly alkaline, with pH ranging from 7.57 to 8.25. The hardness of water fall within the hard to very hard category in majority of the groundwater samples. In the analysis, it has been found that qualitatively most of the groundwater samples fall under the permissible or acceptable limits set by BIS and WHO.

Conclusion:

Most of the results for the physico-chemical parameters indicated satisfactory quality from the perspective of water quality parameters. It is conceivable to conclude that the water in the study region is generally alkaline, hard and the majority of the TDS measurements are within allowable limits. Both the sodium and chloride levels fall within the criteria for acceptable drinking water quality. There is a need for the concerned government organizations to regularly evaluate the quality of the water and create appropriate plans for managing it.

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