ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Volume 11, Issue 7, July 2024

Electrical Conductivity and pH Variations in the Groundwater System of the Burhi Gandak Basin, Bihar, India

[1] Vikas Kumar, [2] Shashank Shekhar

[1][2] Department of Geology, University of Delhi, Delhi, India
Email for correspondence: [1] viku7654@gmail.com, [2] shashankshekhar01@gmail.com

Abstract— ***Burhi Gandak basin is one of the important basins in the northern Bihar, which originates in the district of west Champaran, Bihar and merges with Ganga River in the Khagaria district of Bihar. This study aims for preliminary assessment of electrical conductivity and pH variations in the groundwater system of the basin in context of the hydrogeological domain. Thus, groundwater sample analysis report from various locations of the basin were interpreted for assessment of the electrical conductivity and pH variations. The concentrations of electrical conductivity were observed comparatively lower in the upper part of the Burhi Gandak Basin indicating fresh water dominance zone. The highest recorded value of electrical conductivity was observed to be almost two times greater than the fresh water range (up to 1500 µS/cm). Furthermore, the analysed data shows that Samastipur district had higher Electrical Conductivity within the Burhi Gandak basin. The pH values were higher in the upper part compared to the lower part.***

Index Terms— ***Depth to water level, Electrical Conductivity, pH, Burhi Gandak Basin***

I. INTRODUCTION

Water is an essential component for existing of life of living beings on the Earth. It is the second most important resource after air, which is important for sustaining of life (Gleick 1993). Fresh water is a precious resource for life but due to different anthropogenic activities like change in agriculture practices, excessive use of fertilizers, pesticides, herbicides have added excess nutrient load in water that might have affected the water salinity badly. However, sometimes it is the prolonged sediment-water interaction which enriches salinity. As per UNESCO (1992), "introduction of any substance into water in undesirable concentration not normally present in water, e.g. microorganisms, chemicals, waste or sewage, which renders the water unfit for its intended use is termed as water pollution or contamination of water". The contaminated water can be both surface water as well as groundwater, but groundwater is considered as more important from usable resource point of view. The groundwater contamination problems hold greater relevance in context of developing country like India, Brazil, China etc (Shaji et al. 2021). In the recent days, the changing pattern of development, industrialization, irrigation etc are greatly affecting the groundwater exploitation and its contamination. In India, states like Bihar, Jharkhand etc, which lie in the category of least developing state, are focusing on the development in all sectors. Which is leading to increase in resource utilization from all sectors that ultimately might impact the groundwater condition (CGWB 2022).

The study area is the Burhi Gandak Basin. It's main stream lies entirely in the Northern part of Bihar, which is the part of least developing states of India. In recent years, Indian government has launched various policies/schemes, which specially focus on the development of Eastern States of India. One the important schemes is Second Green Revolution or Krishonnati scheme in 2017, as an integrated scheme for agriculture sector (Balkrishna et al. 2022). The study area has mostly agricultural lands. The main objective is to study variations in the electrical conductivity and pH of the groundwater in context of the hydrogeologic system, so as to lay foundation for further in-depth assessment in to the hydrochemistry.

II. STUDY AREA

The study area is the catchment area of Burhi Gandak river and its tributaries. It is located between 24.435 N to 27.534 N, 84.105 E to 86.520 E (fig. 1) (Kumar 2019). Burhi Gandak river catchment area is surrounded in North by the Bagmathi river system, in Eastern side by Bagmathi – Koshi river system, in Western side by Gandak river system and in Southern side by Ganga River system. The river flows from upper Nepal catchment and confluence with the Ganga River in Katihar district of Bihar. It originates from near Chautwara Chaur of West Champaran Districts. It's origin area lies in the Someshwar range hills at 300 m above sea level. Its main river course lies completely in Bihar territory. However, some left bank tributaries originate from Nepal and confluence in the main course of river in Bihar. The whole catchment area covers across six districts of Bihar.

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Volume 11, Issue 7, July 2024

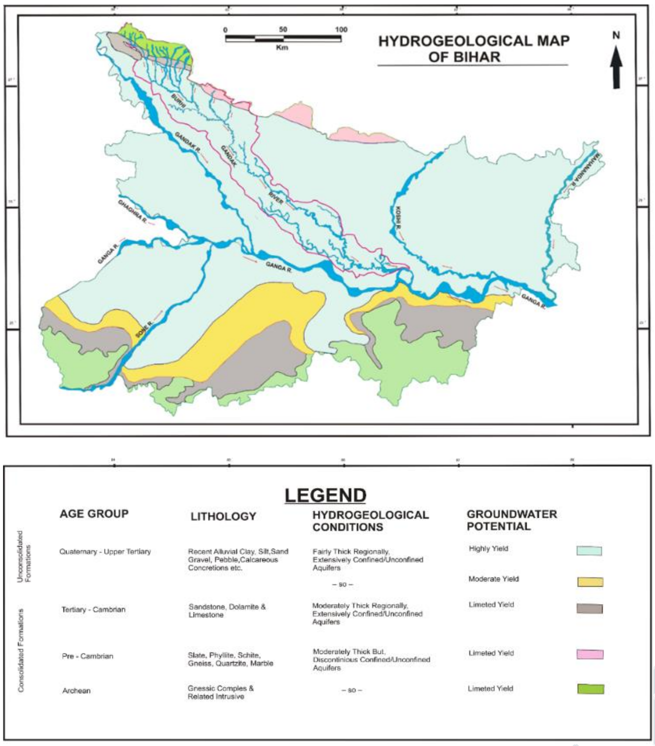

Fig. 1. Geology and hydrogeology of the Burhi Gandak basin study area (Sources - modified after CGWB 2013 & CWC 2015)

III. GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

About 91% of average annual rainfall of this catchment area receives from South - West monsoon between the months of June to October. The total average annual rainfall of this sub basin is 1233 mm (CWC 2015). The basin area lies in the northern part of Bihar (fig. 1). Thus, most of the part of basin has unconsolidated alluvial formation (such as sand, clay & silt) of Quaternary age. This formation consists extensively thick confined/unconfined aquifers with high to moderate yield capacity. The upper most part of the basin is the part of Siwalik range of Tertiary age. The Tarai region has unconsolidated formation. It has moderate yield capacity with moderate thick confined/unconfined aquifers (CGWB 2013).

IV. MATERIALS AND METHODOLOGY

Collection of Samples:

To achieve the objective of the proposed research study, the groundwater samples analysis play vital part. In groundwater sampling, we followed the sampling procedures to minimize sampling error in its final outcomes (Halim et al. 2009). The sampling procedures are as

a) Selection of sites for water sampling:

In this study, the location sites of groundwater sampling was taken from the annual report of CGWB (2020). There were 62 sites in this study area, from where the groundwater samples were collected and analyzed in November 2020 (fig.

b) Selection of sampling container:

The quality of containers was as per standard, which ensures its cleanliness, strength and durability. By doing that, it will be safe during transit from any leakage and breaking issue. Generally, 500ml containers were utilized for groundwater sampling.

c) Water sampling techniques:

For collection of groundwater samples, the sampling method were adopted as per procedure, where water groundwater sample bottles thoroughly cleaned and rinsed 3-4 times from the sampling water. The Groundwater samples were taken only after 15-20 min running of tube wells. Also, the depth of tube wells/hand pumps were recorded by asking from the local people. During sampling on sites, some parameters of water quality were also measured, i.e. EC, pH, Water Level meter, etc. Caps were placed on the groundwater samples bottle safely ensuring any leakages.

During the groundwater sample collection, the electrical conductivity and pH were measured through EC and pH meter in situ. The measurement of electrical conductivity was done with a probe. The unit of measurement for the probe was micro Siemens, or milli Siemens per centimetres. The pH probe was also calibrated through pH 7 and 10 buffer solutions for every groundwater sample (Khola et al. 2013).

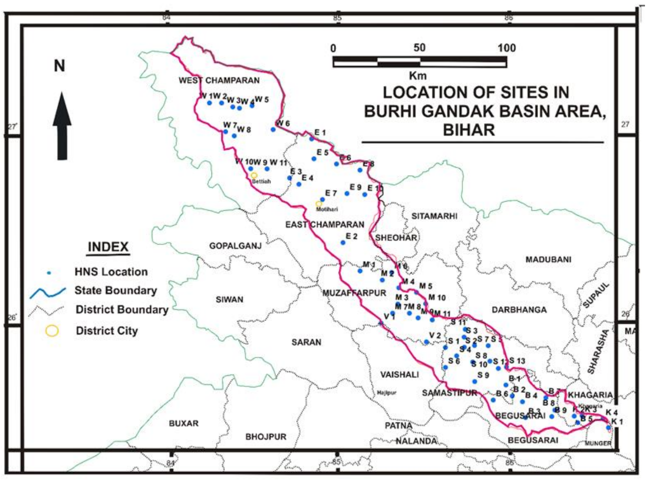

Fig. 2. Groundwater sample sites locations of collected groundwater samples.

V. RESULTS

Water Level Variations

Depth to water level variation throughout the basin showed the average range of 1.08 – 3.99 mbgl (Table 1). Overall, the lower part of the basin showed the higher depth to water level from the upper and middle part of the basin (Fig. 3). However, the fluctuations of the depth to water level throughout the basin remained low. The Water table map indicates unidirectional flow regime, which is topographically controlled (fig. 3). The groundwater flow direction observed towards Southeast to East direction, which is revealing a recharge area near 105m contour line and a local discharge trough near 90m contour line in upper part basin. Overall, the contour line is showing effluent nature of the river. Hydraulic gradient in upper part of basin is slightly more than the middle and lower part of basin and overall, the basin is showing low hydraulic gradient.

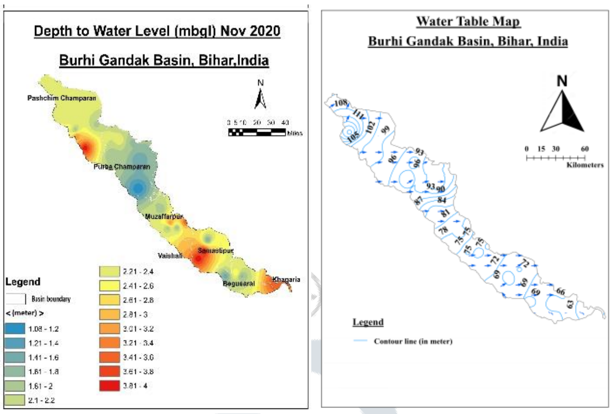

Fig. 3 Depth to water level and water table map of Burhi Gandak Basin.

Table 1.– Depth to water level of the groundwater in the Burhi Gandak basin.

Year	Upper Part Basin			Middle Part Basin			Lower Part Basin			Overall		
Season	**Avg DWL (in mbgl)**	**Max. DWL (in mbgl)**	**Min. DWL (in mbgl)**	**Avg DWL (in mbgl)**	**Max. DWL (in mbgl)**	**Min. DWL (in mbgl**	**Avg DWL (in mbgl)**	**Max. DWL (in mbgl))**	**Min. DWL (in mbgl)**	**Avg DWL (in mbgl)**	**Max. DWL (in mbgl)**	**Min. DWL (in mbgl**
Post monsoon (Nov, 2020)	2.26	3.39	1.08	2.64	3.99	1.58	2.69	3.36	1.5	2.53	3.99	1.08

Electrical conductivity and pH variations throughout the basin

A material's capacity to conduct electrical current through it is measured by its electrical conductivity (EC), which is controlled by the Total Dissolved Solids (TDS). EC is measured in units called Siemens per unit length (e.g., µS/cm). Salinity level is described by two water quality parameters: conductivity (EC) and total dissolved solids (TDS). A straightforward equation that typically expresses the correlation between these two parameters is TDS = k multiplied by EC (in 25 °C). Compared to EC, the procedures of extracting TDS from a water sample is more involved (Rysydi et al. 2018). The electrical conductivity distribution map and concentrations in the groundwater system of the Burhi Gandak basin have shown in fig. 4 and table 2 respectively. When the EC falls between 0 to 1,500 µS/cm, the groundwater is often fresh water (Ahmad et al. 2019). The groundwater sample data (Nov 2020) analysis had shown comparatively higher EC in lower part of basin (avg 1013.71 µS/cm) compared to middle part (avg 816.52 µS/cm) & upper part (avg 597.0 µS/cm) of basin and the overall EC was avg 816.03 µS/cm in the basin (Table 2) (fig. 4). On the basis of EC range, it is clear that lower part of basin is slightly more saline. The highest EC was observed at the Rosera, Samastipur district (2510.0 µS/cm). The lowest salinity was observed at Banaspur Pipra, West Champaran district (307 µS/cm) in upper part basin, which indicates the area of substantial recharge and this phenomenon (substantial recharge) was also evinced through groundwater level contour map (fig. 3). The pH distribution map based on the analyzed collected groundwater samples (Nov, 2020) is shown as fig. 4, the pH value was slightly higher in upper part of basin (avg 7.52) as compare to middle part (avg 7.51) & lower part (avg 7.09) of basin and the overall average pH value of basin is 7.37 (Table 2).

Table 2. EC and pH concentrations in the upper, middle and lower parts of the Burhi Gandak basin

Constituents	**Upper Part Basin**		**Middle Part Basin**		**Lower Part Basin**		**Total**	
	Range	Average	Range	Average	Range	Average	Range	Average
pH	7.01 - 7.93	7.52	7.3 - 7.73	7.51	6.81 - 7.59	7.09	7.01 - 7.73	7.37
EC (µS/cm)	307 - 1299	597	495 - 1608	816.52	519 - 2510	1013.71	307 - 2510	816.03

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Volume 11, Issue 7, July 2024

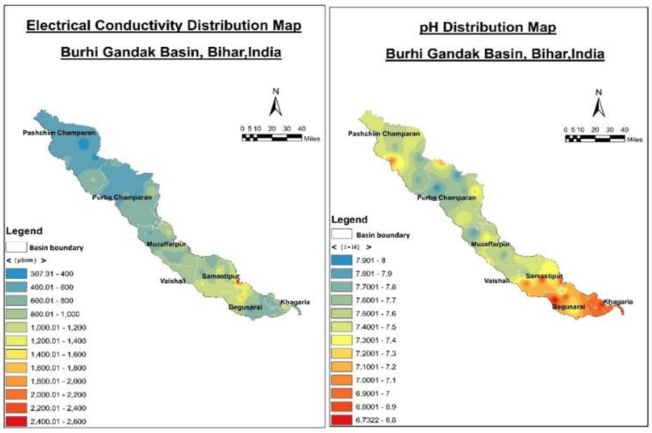

Fig. 4 Electrical conductivity and Ph distribution maps of the Burhi Gandak Basin

VI. CONCLUSIONS

The above analyses are based on the primary data of collected groundwater samples of the Burhi Gandak Basin. Which shows the considerable change in the electrical conductivity and pH values of the groundwater system. The average value of electrical conductivity in the upper part of the basin was observed to be lower compared to the lower part of the Burhi Gandak Basin. This could be attributed to longer residence time of groundwater in the expected finer sediments of the lower part of the basin, which is also a groundwater discharge area. The observed relatively higher pH in the upper part compared to the lower part is a matter of further in-depth investigation. The variations in EC/TDS and pH desires a further in-depth hydro-chemical study in the area.

ACKNOWLEDGEMENTS

The article is part of the Ph.D. work of Vikas Kumar under supervision of Prof. Shashank Shekhar. The article has been discussed at the International Conference on Geological and Environmental Sustainability (ICGES - 24), 6th July 2024, Chennai, India, and has been reported in the proceedings of the seminar. It is published as an article here by prior written permission/consent of the publisher of the proceedings, SFE Explore, obtained by this journal, that is **IJERMCE**.

REFERENCES

[1]. Ahmad, S., & Khurshid, S. (2019). Hydrogeochemical assessment of groundwater quality in parts of the Hindon River basin, Ghaziabad, India: implications for domestic and irrigation purposes. SN Applied Sciences, 1, 1-12.

[2]. Balkrishna, A. K., Arya, V., Sharma, G., Srivastava, D., Sharma, A., & Khan, N. (2022). Situational Analysis of Government Initiatives for the Welfare of Farmers in India: Impact and Futuristic Insights. Indian Journal of Ecology, 49(3), 1023-1035.

[3] CGWB (2013). Ground Water Information Booklet, Samastipur and Muzaffarpur District, Bihar State, Central Ground water Board, Ministry of Water Resources, (Govt. of India), Mid-Eastern Region, Patna.

[4]. Central water commission (CWC), National water mission, Ministry of Water Resources, River Development and Ganga Rejuvenation, Govt. of India. Basin Flood Management Plan for Burhi-Gandak, Bihar (2015).

[5]. CGWB (2020). Ground Water Annual Repart, Bihar State, Central Ground water Board, Ministry of Water Resources, (Govt. of India), Mid-Eastern Region, Patna.

[6]. CGWB (2022). National compilation on Dynamic Groundwater resources of India 2022, Central Ground water Board, Department of water resources, River Development and Ganga Rejuvenation, Ministry of Jal Shkati, (Govt. of India).

[7]. Gleick, P. H. (1993). Water in crisis (Vol. 100). New York: Oxford University Press.

[8]. Halim, M. A., Majumder, R. K., Nessa, S. A., Hiroshiro, Y., Uddin, M. J., Shimada, J., & Jinno, K. (2009). Hydrogeochemistry and arsenic contamination of groundwater in the Ganges Delta Plain, Bangladesh. Journal of hazardous materials, 164(2-3), 1335-1345.

[9]. Khola, R. K. (2013). Analysis of electrical conductivity of ground water at different locations of Bhadaura of UP. Journal for Pharmaceutical Research Scholars, 2(4), 107-109.

[10]. Kumar, A (2019). Ground Water Resource Its Appraisal, Conservation and Planning : A Case Study of West Champaran District.

[11]. Rusydi, A. F. (2018). Correlation between conductivity and total dissolved solid in various type of water: a review, IOP conference series: Earth and environmental science. IOP Publishing. doi, 10, 1755-1315.

[12]. Shaji, E., Santosh, M., Sarath, K. V., Prakash, P., Deepchand, V., & Divya, B. V. (2021). Arsenic contamination of groundwater: A global synopsis with focus on the Indian Peninsula. Geoscience frontiers, 12(3), 101079.

[13]. Mishra, D. S. (2009, May). Safe drinking water status in the state of Bihar, India: Challenges ahead. In Water, sanitation and hygiene-Sustainable development and multisectoral approaches: Proceedings of the 34th WEDC International Conference, Addis Ababa, Ethiopia (pp. 18-22). cc WEDC, Loughborough University.

[14]. Peter, H. G. (1993). Water and conflict: fresh water resources and international security. International Security, 18(1), 79-112.

[15] UNESCO. International Glossary of Hydrology. 2nd edn, UNESCO, Paris, France; 1992. p. 413.