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Monitoring and Assessment of Subarnarekha River Water Quality Using Water Quality Index

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Subarnarekha river is the lifeline of tribal communities and fishing communities, residing on the riverbanks and their life and livelihood is affected by the river's pollution. The purpose of this study is to determine the water quality status of Subarnarekha River in Ranchi. River water samples were analyzed for physio-chemical parameters such as pH, Turbidity, DO, BOD_3, Total hardness, Alkalinity, Chloride, Phosphorus and Chromium. After the physio-chemical analysis, Water Quality Index (WQI) was established for these 9 physio-chemical parameters by following the weighted arithmetic method. Water samples were collected from 8 different sampling locations from the month of January 2024 to May 2024. Subarnarekha river water quality falls between the category of excellent to acceptable as per WQI, as it ranged between 6.76 - 26.4. The WQI value of Site 1 and Site 2 falls under the excellent category throughout the observation period, expect in the month of April; water is fit for drinking, bathing and aquatic life.

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Keywords: Subarnarekha river; water quality index; physio-chemical parameters; pollution.

1. INTRODUCTION

River water is considered as the most important natural resource. It has played a vital role in connecting and channelizing the natural components of the basin such as land, forest, vegetation productivity and animals. All human needs are dependent on the availability of water resources [1,2]. Access to fresh water is often taken for granted, especially in developed countries that have built sophisticated water systems for collecting, purifying, and delivering water, and removing waste water. But growing economic, demographic, and climatic pressures are increasing concerns about water issues, leading to increasing competition for fixed water resources [3,4]. The day by day increasing demand of water has developed new methods of water quality assessment and management [5].

Monitoring of river water is necessary especially where the water serves as drinking sources and where it is threatened by pollution resulting from various human activities along the river course [6,7]. The waste discharged from industries have affected the water bodies as well as aquatic life, resulting in poor water quality. Not only industries but the fertilizers used in agriculture has also affected the river bodies in large scale [8].

Subarnarekha is a rainfed river flowing in the eastern part of India, sustaining millions of people of Jharkhand, West Bengal and Orissa [9]. The river water has been used by different agencies for various purposes. In industry it is used as a direct process input and as a disposal agent for the dilution of effluents; by agriculturists for irrigation; by household sector for drinking and other domestic use [10,11]. The basin therefore needs careful environmental management planning to protect its continued existence [12,13,14].

2. MATERIALS AND METHODS

The experiment was conducted on Subaranarekha River in Ranchi, Jharkhand during the month of January 2024 to May 2024. Water samples were collected from 8 different sampling sites i.e Nagri (S1), Dhurwa (S2), Hatia (S3), Chutia (S4), Namkum (S5), Tatisilwai(S6), Mesra (S7) and Rukka (S8). The sampling sites were selected to cover various anthropogenic activities such as pollution through industrialization, agricultural runoff, dumping of waste and disposal of untreated water into river.

2.1 Sampling Area

The Subarnarekha river is one of the longest east flowing inter-state rivers. It originates from Nagri village (23° 18′ 02″N and 85° 11′ 04″E) in the Ranchi district of Jharkhand at an elevation of 600 m. Subarnarekha basin extends over states of Jharkhand, Odisha and comparatively smaller part in West Bengal having a total catchment area of 19,296 km^2.

2.2 Collection and Preservation of Samples

Water samples were collected during the month of January 2024 to May 2024 (5 months), from 8 different sampling locations along the route of the Subarnarekha River basin in Ranchi. The samples were collected in the morning hours between 5 am to 11 am in clean air tight bottles without any contamination. The bottles were first thoroughly rinsed by the sample water itself and then the water sample was collected. After the collection of samples, they were properly labeled according to its respective location notations in the field and further preserved for physio-chemical analysis in the laboratory.

2.3 Sampling Frequency

Samples were collected and analyzed in every 15 days of interval i.e. twice a month.

2.4 Analysis of Collected Samples

After the collection of water samples from different locations, the water samples were analyzed in the laboratory of Biocrat Environmental Services, Ranchi using standard methods, for the examination of physio-chemical parameters. The parameters which were analyzed are pH, Turbidity, Dissolved oxygen, Biological oxygen demand, Total hardness, Alkalinity, Chloride, Phosphorus and Chromium as mentioned in the Table 1.

2.5 Sampling Sites

Water samples were collected from different sampling sites starting from Site 1 to Site 8, covering a total river stretch of 67.5 km as mentioned in Table 2, with the description of sampling location.

Table 1. Water Quality Parameters, Unit & Methods Used For The Analysis

S.No.	Parametes	Unit	Methods
1.	pH	-	Digital pH Meter (Jackson, 1958)
2.	Turbidity	NTU	Nephelometric Method (APHA 1995)
3.	Dissolved Oxygen	mg/l	Winkler Method (Trivedy & Goel, 1984)
4.	Biological Oxygen Demand	mg/l	Winkler Method (Trivedy & Goel, 1984)
5.	Total Hardness	mg/l	EDTA Method (Trivedy & Goel, 1984)
6.	Alkalinity	mg/l	Titration Method (Moser, 1976)
7.	Chloride	mg/l	Argentometric Titration (Mc Farland, 1983)
8.	Phosphorus (P)	mg/l	Spectrophotometric Method
9.	Chromium (Cr)	mg/l	Spectrophotometric Method

Table 2. Sampling sites of Subarnarekha river at Ranchi, Jharkhand

S.No.	Sampling Location	Site Notation	Distance from S1	Sampling Location Description
1.	Nagri	S1	0 km	Origination point of river
2.	Dhurwa	S2	14 km	Town Area
3.	Hatia	S3	18.7 km	Town Area
4.	Chutia	S4	30.7 km	City Area
5.	Namkum	S5	35.5 km	Industrial Area
6.	Tatisilwai	S6	44.1 km	Industrial Area
7.	Mesra	S7	59.1 km	Town Area
8.	Rukka	S8	67.5 km	Rural Area

2.6 Map of Study Area

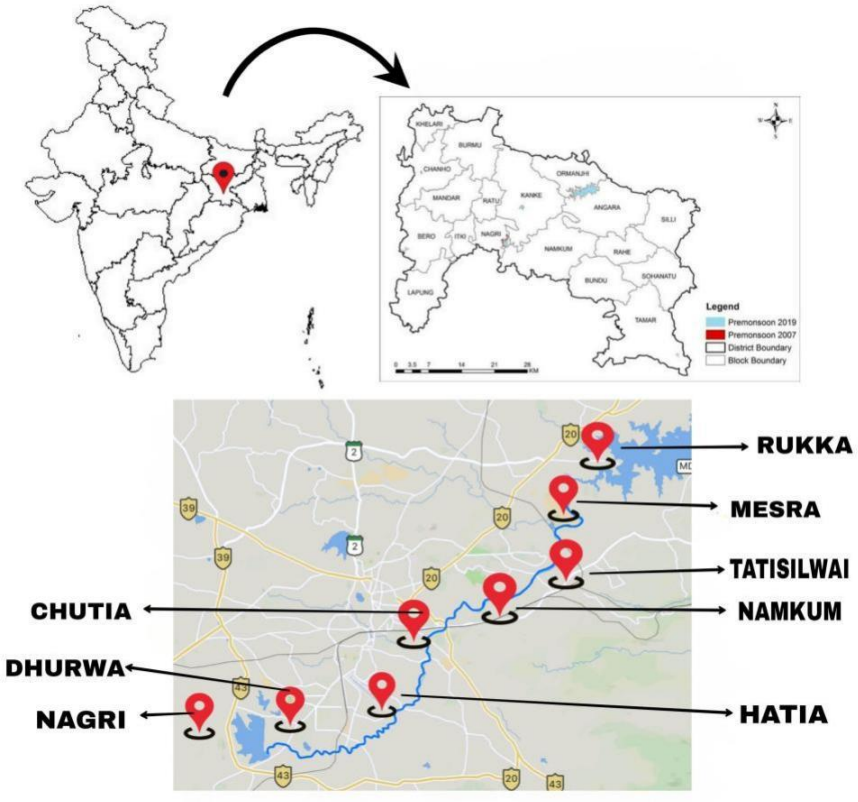

Fig. 1. Map of Subarnarekha river showing the sampling site

2.7 Water Quality Index (WQI)

Water Quality Index (WQI) was developed by Horton with approach of mathematical calculation with single value to represent the multiple water quality parameters [15]. Thereafter considerable advances have been made based on the principle of WQI using slightly modified concepts [5,16,17,18,19,20,21,22]. The weighted arithmetic method has been used for calculating the WQI for several Indian rivers [23,24,15,25].

The WQI is calculated by transforming the raw data into a common scale, providing weights to each parameter, and aggregating the sub-index values [26]. In the present study, developed sub-index curve was used to calculate the sub-index which was referred from (Singh *et al*., 2008), as well as the pollutant weight [24]. All total nine parameters are used for the calculation of WQI i.e. pH, Turbidity, DO, BOD_3, Total Hardness, Alkalinity, Chloride, Phosphorus and Chromium. Parameters were chosen based on their direct relevance to established water quality standards and guidelines and the availability of reliable data also influenced the parameter selection. The formula used to determine the water quality index can be noticed in the following arithmetic expression:

$$WQI = \sum [Pi.Wi]$$

Where,

Pi is the sub-index value;
Wi is the weight of each parameter.

3. RESULTS AND DISCUSSION

The river water quality of Subarnarekha River was determined in terms of Water Quality Index (WQI) using 9 selected parameters viz. pH, Turbidity, DO, BOD, Total Hardness, Alkalinity, Chloride, Phosphorus and Chromium. Water quality index in the historical and the present study is established from various important physio-chemical parameters in different months. The value of the water quality index varied depending on the site; a lower value indicates excellent water quality (0–10), while a higher value indicates acceptable water quality (11-28), slightly polluted (29–51), moderately polluted (51-69), and severely polluted (69 above) conditions.

3.1 Water Quality Assessment using WQI for the Month of January

The Water Quality Index was used to analyze the water quality for the month of January and the result showed that Tatisilwai (S6) had the highest value i.e. 25.8, while Nagri (S1) had the lowest value i.e. 6.76. According to water quality rating, the variance in WQI values at the sites, Nagri (S1) and Dhurwa (S2) falls under the excellent category, while the sampling site from Hatia (S3) to Rukka (S8) falls under the acceptable category. The possible reason for change in the class is due to the contamination of water during the observation period. (as shown in Table 3 (a) and (b) and Fig. 2 (a) and (b).

Table 3(a). Water Quality Rating (Nath, S. 2007) [19]

Purpose	Classification				
	Excellent	Acceptable	Slightly polluted	Moderately polluted	Severely polluted
	Class I	Class II	Class III	Class IV	Class V
Drinking purpose	0-10	11-28	29-51	51-69	69 above
Bathing	0-10	11-30	31-61	62-85	85 above
Aquatic life	0-9	10-28	29-53	54-70	70 above

Table 3(b). WQI for month of January at different sites of Subarnarekha river

Sites	S1	S2	S3	S4
WQI Value	6.76	10.7	14.6	22.2
WQI Status	Excellent	Excellent	Acceptable	Acceptable

Table 3 (c). WQI for month of January at different sites of Subarnarekha river

Sites	S5	S6	S7	S8
WQI Value	23.4	25.8	18.9	14.3
WQI Status	Acceptable	Acceptable	Acceptable	Acceptable

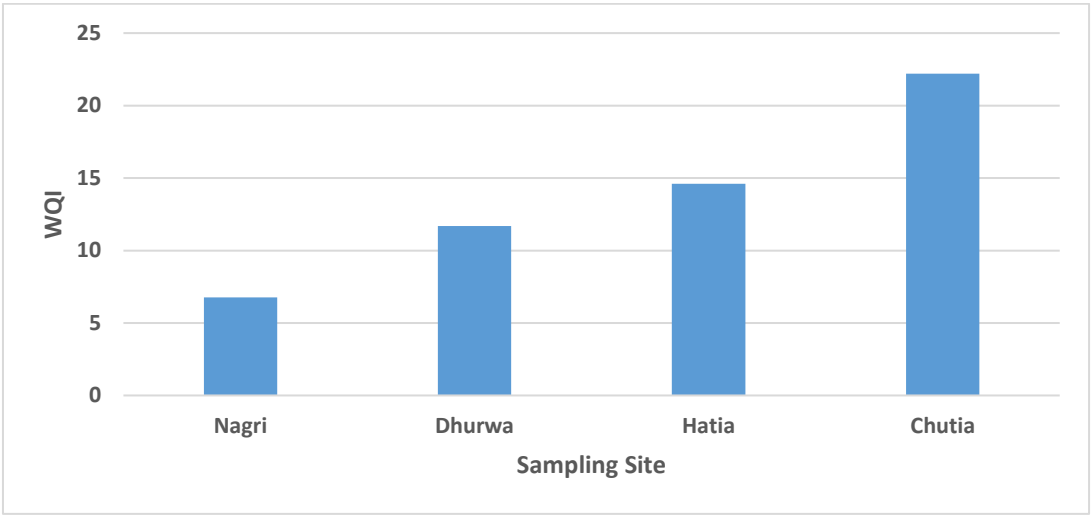

Fig. 2 (a). WQI for the month of January at different sites Subarnarekha river

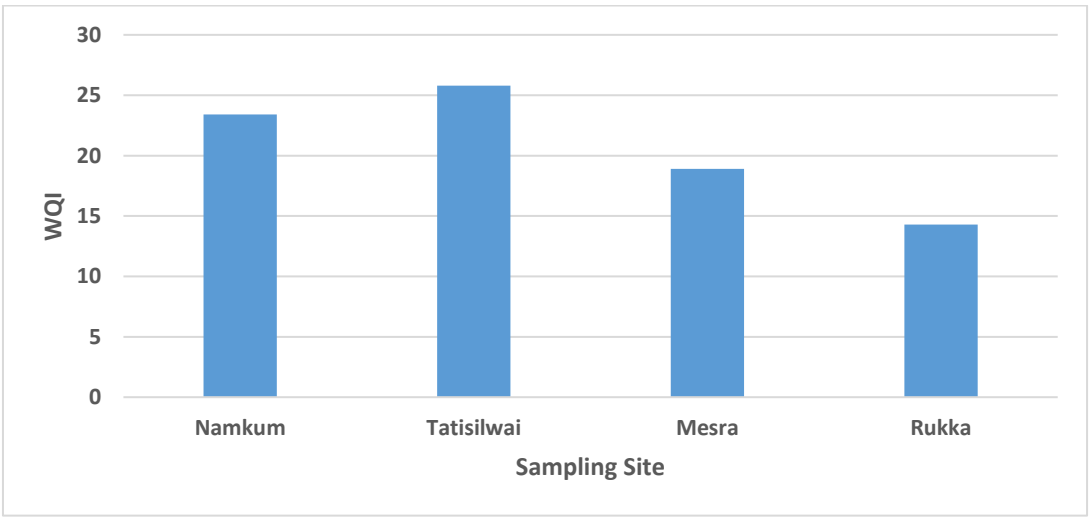

Fig. 2(b). WQI for the month of January at different sites Subarnarekha river

Table 4(a). WQI for month of Feburary at different sites of Subarnarekha river

Sites	S1	S2	S3	S4
WQI Value	10.1	8.43	12.6	23.3
WQI Status	Excellent	Excellent	Acceptable	Acceptable

Table 4(b). WQI for month of Feburary at different sites of Subarnarekha river

Sites	S5	S6	S7	S8
WQI Value	23.6	25	17	12.8
WQI Status	Acceptable	Acceptable	Acceptable	Acceptable

3.2 Water Quality Assessment using WQI for the Month of February

The Water Quality Index was used to analyze the water quality for the month of February and the result showed that Tatisilwai (S6) had the highest value i.e. 25, while Dhurwa (S2) had the lowest value i.e. 8.43. According to water quality rating, the variance in WQI values at the sites, Nagri (S1) and Dhurwa (S2) falls under the excellent category, while the sampling site from Hatia (S3) to Rukka (S8) falls under the acceptable category. The possible reason for change in the class is due to the contamination of water during the observation period. (as shown in Tables 4(a) and (b) and Figs. 3(a) and (b).

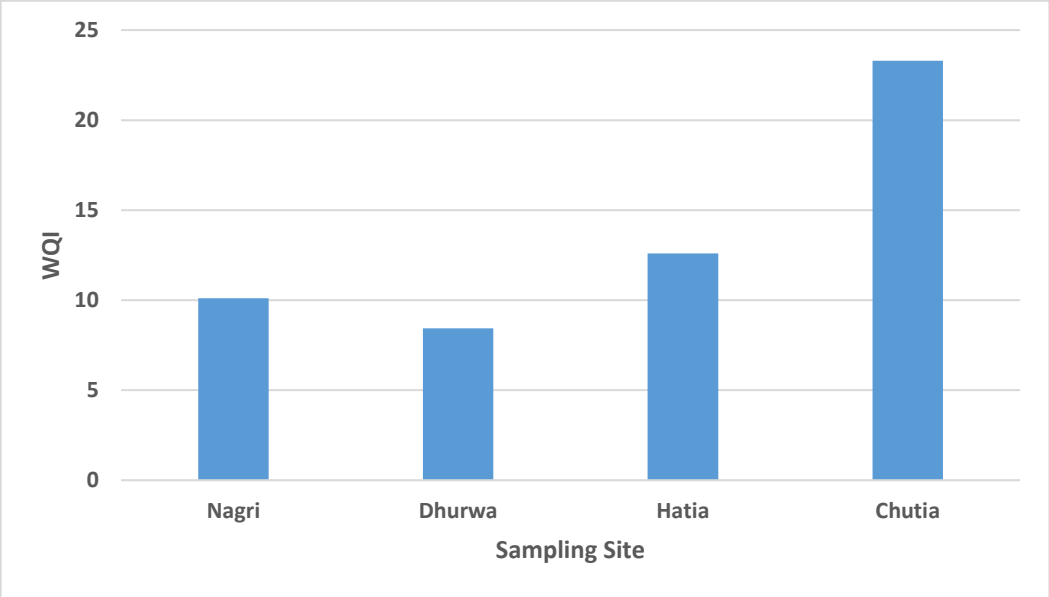

Fig 3(a). WQI for the month of February at different sites Subarnarekha river

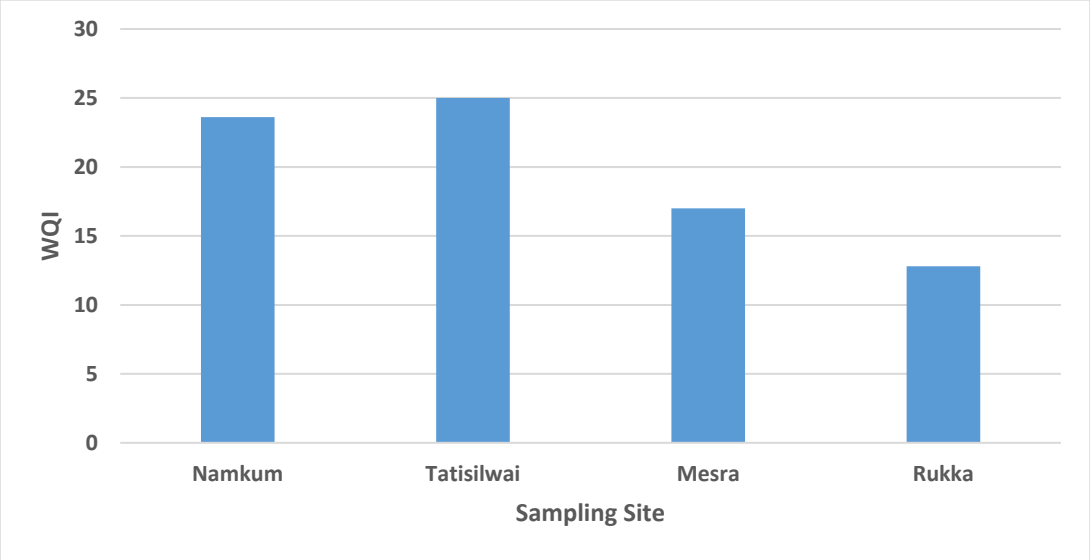

Fig 3(b). WQI for the month of February at different sites Subarnarekha river

Table 5(a). WQI for month of March at different sites of Subarnarekha river

Sites	S1	S2	S3	S4
WQI Value	10.3	9.85	12.4	25.5
WQI Status	Excellent	Excellent	Acceptable	Acceptable

Table 5(b). WQI for month of March at different sites of Subarnarekha river

Sites	S5	S6	S7	S8
WQI Value	24.1	24.2	18.4	14.3
WQI Status	Acceptable	Acceptable	Acceptable	Acceptable

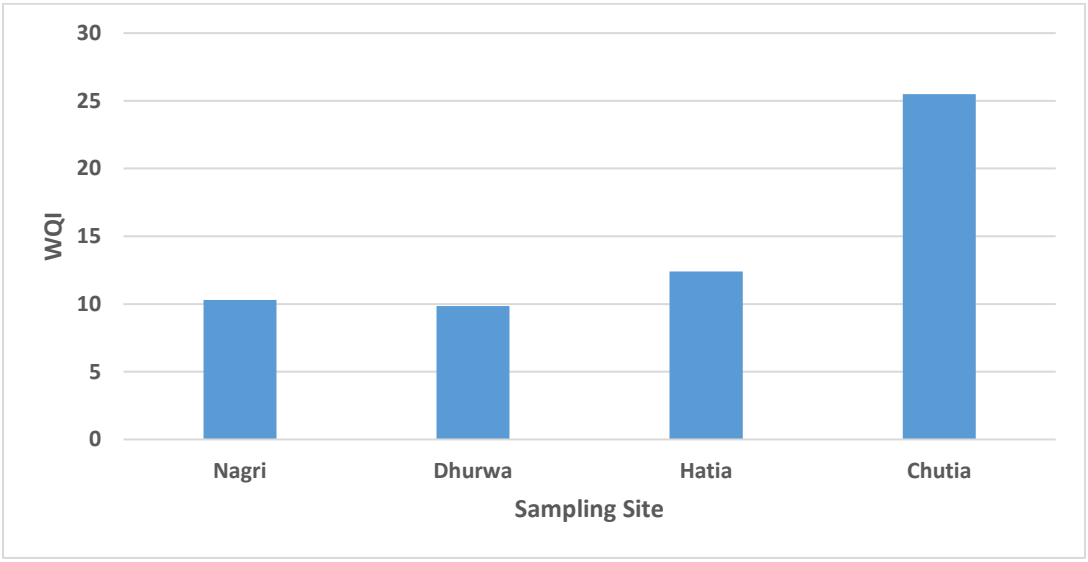

Fig 4(a). WQI for the month of March at different sites Subarnarekha river

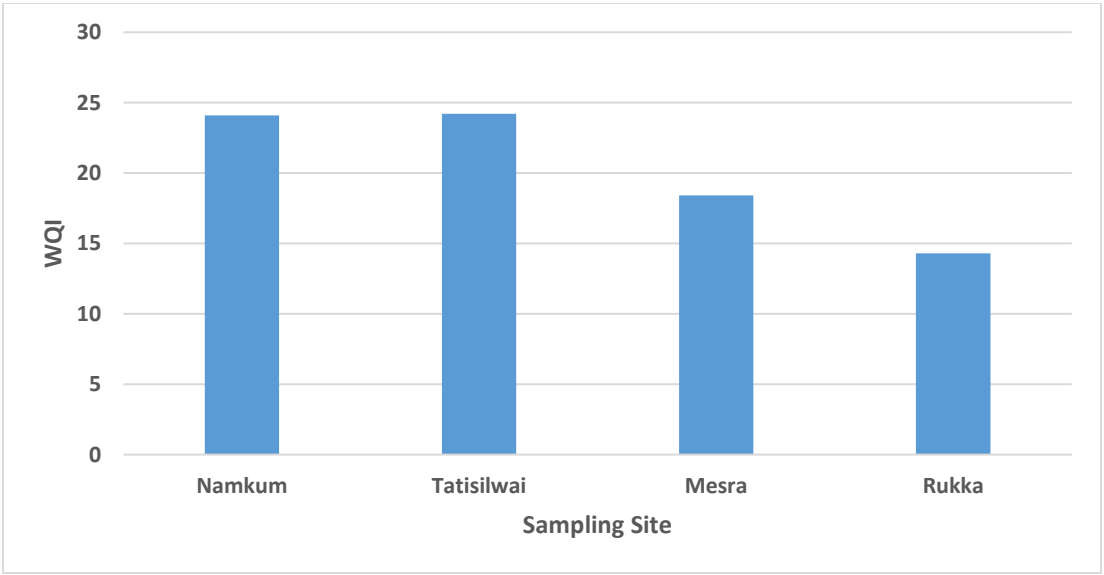

Fig 4(b). WQI for the month of March at different sites Subarnarekha river

3.3 Water Quality Assessment using WQI for the Month of March

The Water Quality Index was used to analyze the water quality for the month of March and the result showed that Chutia (S4) had the highest value i.e. 25.5, while Dhurwa (S2) had the lowest value i.e. 9.85. According to water quality rating, the variance in WQI values at the sites, Nagri (S1) and Dhurwa (S2) falls under the excellent category, while the sampling site from Hatia (S3) to Rukka (S8) falls under the acceptable category. The possible reason for change in the class is due to the contamination of water during the observation period. (as shown in Tables 5(a) and (b) and Figs. 4(a) and (b).

3.4 Water Quality Assessment using WQI for the Month of April

The Water Quality Index was used to analyze the water quality for the month of April and the result showed that Chutia (S4) had the highest value i.e. 26.4, while Nagri (S1) had the lowest value i.e. 11.1. According to water quality rating, the variance in WQI values of all the sites i.e. Nagri (S1), Dhurwa (S2), Hatia (S3), Chutia (S4), Namkum (S5), Tatisilwai (S6), Mesra (S7) and

Rukka (S8) falls under the acceptable category according to water quality rating. The possible reason for all the sites to fall under the category of acceptable is slightly high contamination of water during the observation period. (as shown in Tables 6(a) and (b) and Figs. 5(a) and (b).

Table 6(a). WQI for month of April at different sites of Subarnarekha River

Sites	S1	S2	S3	S4
WQI Value	11.1	11.2	13	26.4
WQI Status	Acceptable	Acceptable	Acceptable	Acceptable

Table 6(b). WQI for month of April at different sites of Subarnarekha river

Sites	S5	S6	S7	S8
WQI Value	24.1	24.5	22.7	14.3
WQI Status	Acceptable	Acceptable	Acceptable	Acceptable

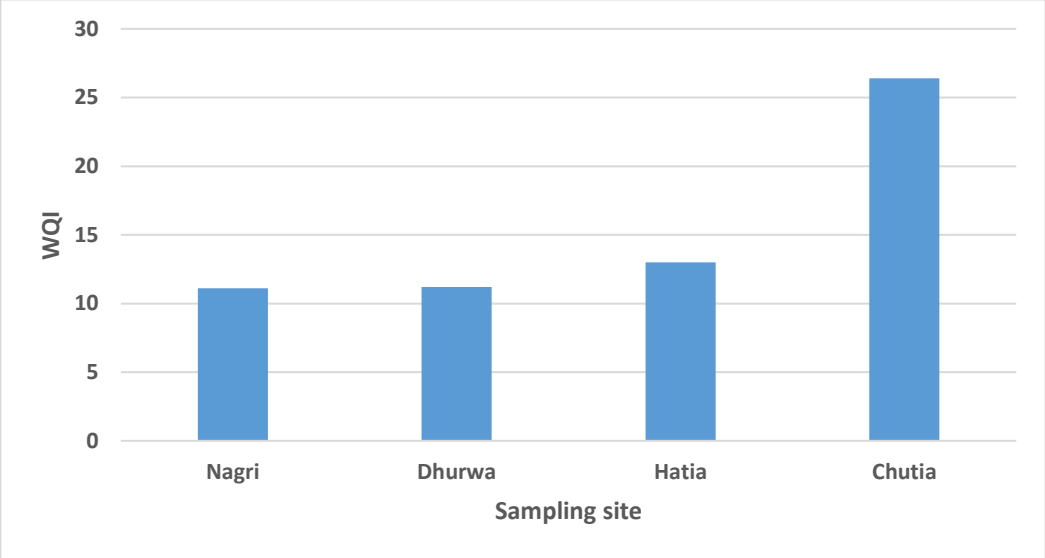

Fig 5(a). WQI for the month of April at different sites Subarnarekha river

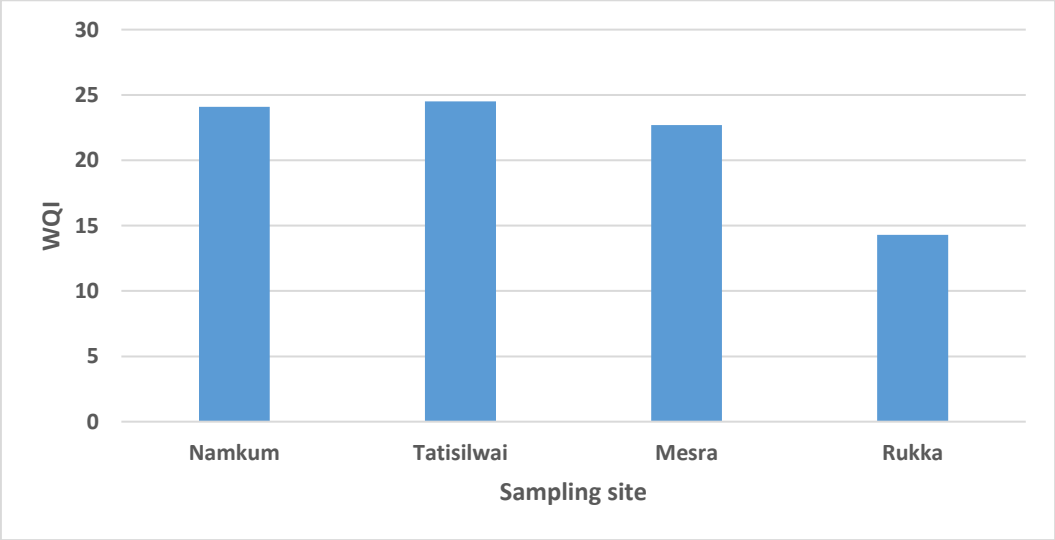

Fig 5(b). WQI for the month of April at different sites Subarnarekha river

Table 7(a). WQI for month of May at different sites of Subarnarekha river

Sites	S1	S2	S3	S4
WQI Value	10.8	10.9	13.1	25.2
WQI Status	Excellent	Excellent	Acceptable	Acceptable

Table 7(b). WQI for month of May at different sites of Subarnarekha river

Sites	S5	S6	S7	S8
WQI Value	22.9	26.2	19.5	15.7
WQI Status	Acceptable	Acceptable	Acceptable	Acceptable

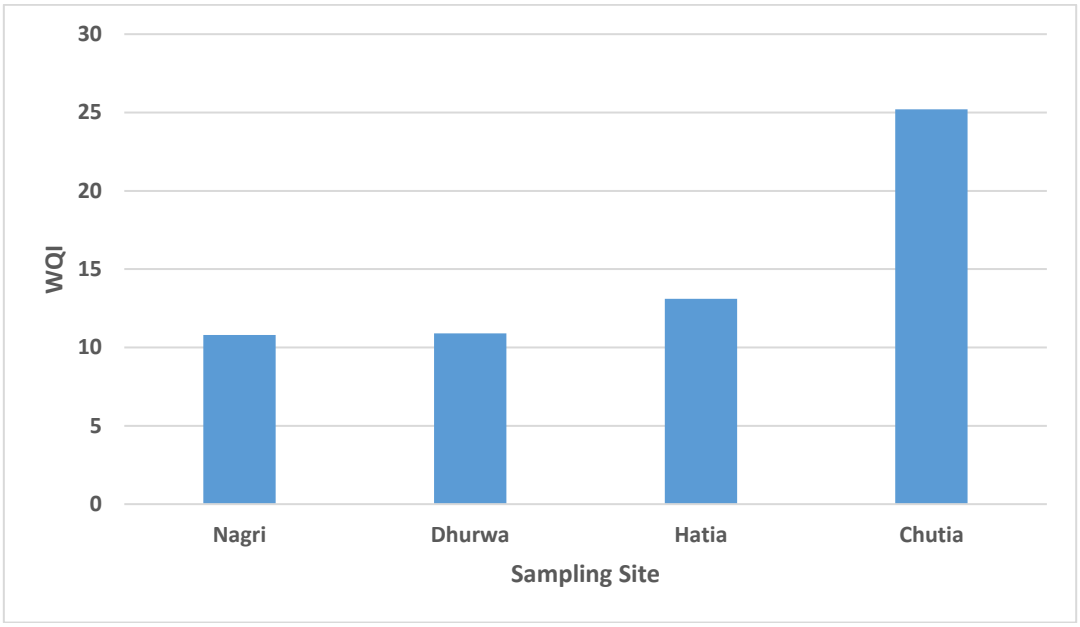

Fig 6(a). WQI for the month of May at different sites Subarnarekha river

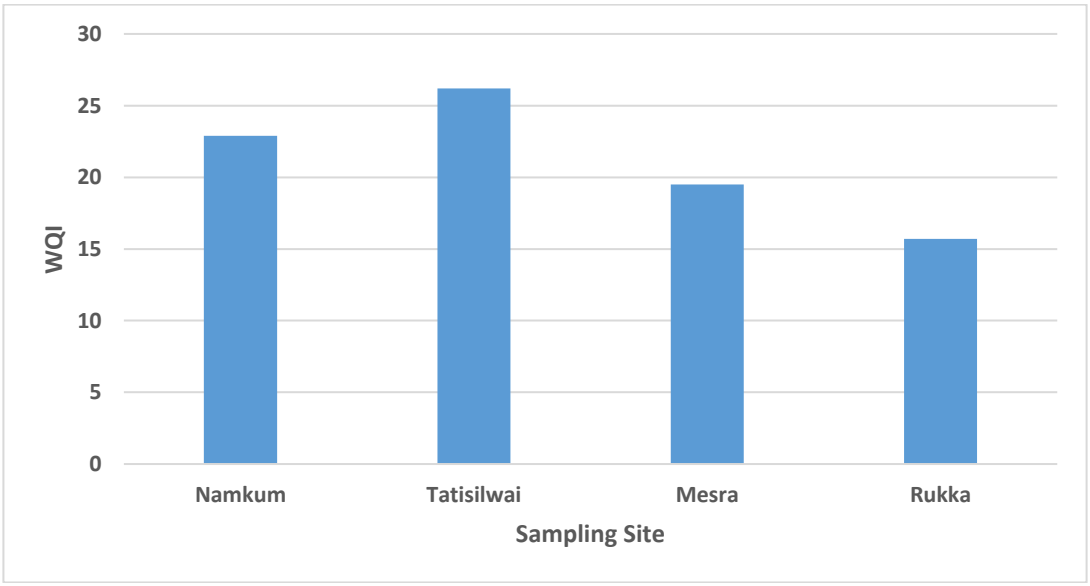

Fig 6(b). WQI for the month of May at different sites Subarnarekha river

3.5 Water Quality Assessment using WQI for the Month of May

The Water Quality Index was used to analyze the water quality for the month of May and the result showed that Tatisilwai (S6) had the highest value i.e. 26.2, while Nagri (S1) had the lowest value i.e. 10.8. According to water quality rating, the variance in WQI values at the sites, Nagri (S1) and Dhurwa (S2) falls under the excellent category, while the sampling site from Hatia (S3) to Rukka (S8) falls under the acceptable category. The possible reason for change in the class is due to the contamination of water during the observation period. (as shown in Tables 7(a) and (b) and Figs. 6(a) and (b) [27,28].

4. CONCLUSION

Subarnarekha river water quality falls between the category of excellent to acceptable as per WQI, as it ranged between 6.76 - 26.4. For Site 1 and Site 2, the WQI value falls under the excellent category throughout the observation period, expect in the month of April. The river water from the originating point is categorized as excellent, however the possible reason for slight variation in water quality index at various other sampling site beyond the originating point is anthropogenic activities.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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