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A review of studies done at Barna streams for the assessment of ecological health of tributaries at Barna stream network of Narmada river basin

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Abstract
The present study finds and review the different work carried on Barna stream network with present status of water quality examined during the period 2020-2021. The review provides a single document containing the various works carried till date and their findings on the present study area at Barna stream network. Various research papers have been studied and their important findings are presented in the paper which will guide and help the researcher in future studies. The Barna stream network consist of six tributaries out of which Barna, Jamner and Narheri are found to be in optimal condition by the different researches. The streams Satdhar, Chamarsil were found to be in fair condition and Palakmati stream was found to be disturbed under anthropogenic pressures.

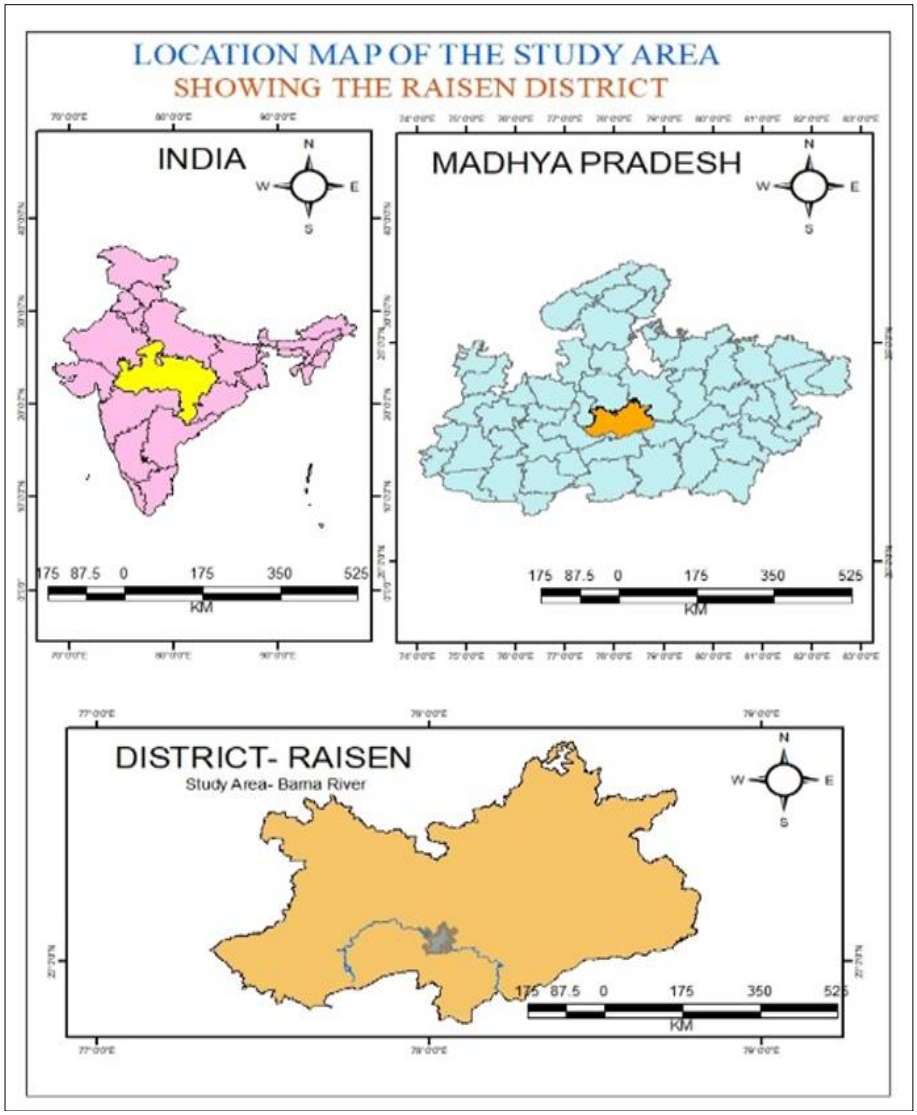
Keywords: Physcicochemical parameters, surface water, stream network

Introduction
Water covers over 70% of the Earth's surface. Despite this, only about 1% of the water on the planet is genuinely fresh and usable. The limited surface water resources in India, combined with the country's robust population, necessitate the use of water resources for drinking water and residential purposes in a wisely manner [15]. However, rising population, rapid industrialization, intensification of agriculture, and urbanisation all put a strain on our vast but finite water resources, resulting in water contamination and health issues. According to the World Health Organization, water is responsible for around 80% of all human diseases. 3 As a result, there is always a need for and concern about surface water quality protection and management.

The Barna Stream is about 2. 5 kilometers NW of Barikhurd town, Tehsil Bari, Raisen District. The project is located 8 kilometers away from Bari (12 National Highway (Jabalpur, Jaipur)). The nearest station is Obedullaganj on the Central Railway, 66 kilometers from the location of the Dam. The project is located at a distance of kilometers and 100 kilometers away from the capital Bhopal [6]. Barna stream network provides water to agricultural activities and several other purposes. Barna stream network also serves as a habitat for various ecological species and also supplies water to the major lifeline of India river Narmada. Though major part of the river contains some water throughout due to reservoir but major portion of the stream does not contain any potential source of water during the summer season.

Humans also intervene in the hydrology of streams and rivers through changes in land use (including urbanization, forest-agricultural transition, or other impacts). There are consequences for water resources and water catchment management, including water balance components (such as surface runoff, infiltration/groundwater runoff, and evapotranspiration), potential water shortages, and riverbank Hydrological changes and urban flooding [8-11].

Barna stream network composes of various streams which flows through hilly area, forest, agricultural field, and town which washes off and transport some of the essential nutrients which provide a base for ecological health and growth, however there are some of the area with human intervention which pollutes the water not to a much extent but may be controlled with a better management and solution practices with the community participation and awareness.



Materials and Methodology

Various papers has been reviewed to find work which was carried till date on the Barna stream network by different researchers. Present study work has also been incorporated which was mainly focused on the tributaries of the Barna river. The Location of different tributaries is provided in Table 1. The methodology covers the sampling of water at several locations at the site given in the table 1.

Table 1: Showing coordinates of the study area and different streams

S. No	Substreams	Latitude	Longitude
1	Barna	23° 4'26. 21"N	77°45'43. 34"E
2	Satdhar	23° 6'8. 64"N	77°55'21. 17"E
3	Jamner	23° 4'19. 52"N	77°57'39. 08"E
4	Palakmati	23° 8'6. 98"N	77°55'58. 83"E
5	Chamarsil	23° 9'59. 79"N	77°57'43. 98"E
6	Narheri	23°11'35. 70"N	78° 4'10. 10"E

The present study was conducted during Winter, Summer, Monsoon season in 2020-2021 on the Barna stream network located at 23° 4'26. 21"N latitude, 77°45'43. 34"E longitude. Barna is a major tributary of Narmada along with several other major tributaries. Barna along with its several others substreams such as Jamner, Satdhar, Palakmati, Chamarsil, Narheri forms a stream network called as Barna stream Network. These all streams flows into a irrigation reservoir which was built on Barna river which is also known as Barna Reservoir which lies in 23° 2'11. 13"N lat and 78° 1'34. 46"E longitude near Bari. Barna reservoir is also a indentified wetland under National wetland conservation programme. The River originates from the Vindhya Mountains in Raisen District east of the village Barkhera. Elevation is 450 meters ASL, at 22 55' N latitude and Long 77 44' E [7]. The total area of the basin is 1787 square kilometers. The distance from the union of the Narmada River with Barna from the source is 60. 0 kilometers [7].

Results and Discussion

Environment impact study on Barna reservoir

The growth of the economy and ecology as a result of this irrigation project is examined critically in this research. The health advantages outlined in the project report are contrasted with the actual benefits that are accruing [24]. The project's impact is examined with regarding the depth of the groundwater, the quality of drinking water, rainfall, health implications, and awareness of preservation of life, development of the dairy culture, etc. Thus, this essay provides a critical analysis of Development of the area's economy and ecology as a result of the installation of this irrigation project. This case study places a strong emphasis on the need for water resources development to be environmentally conscious. The Barna Project's building contributed to the eco-technological advancement that lifted

the villagers higher. By making the best use of available resources and transferring irrigation and agriculture-related technology, this project's construction ensures sustainable integrated development while also supplying infrastructure for sustainable development, marketing, and self-employment Shrivastava and dave (2007) [24].

Water quality index

Earlier survey's findings revealed that the WQI score at six stations in the Barna stream network was between 26 to 50, indicating "Good" water quality at each site, showing the robust ecological conditions in the Barna watershed [25]. Present study revealed ovrall good water quality overall except some level of disturbances in Palakmati stream at Barna stream network.

Composition and distribution of functional feeding groups of macroinvertebrates

The Barna sub-basin macroinvertebrate communities' functional feeding groups' abundance and composition were examined in the current study. Five main macroinvertebrate functional feeding groups gatherers, filter-collectors, predators, shredders, and scrapers were identified throughout the survey. In the Barna sub-basin of the Narmada River basin, scrapers and gathering-filterers dominated functional feeding groups in terms of relative abundance [26]. They each provided 61% and 18% of the entire population of benthic macroinvertebrates. Additionally, it was found that the makeup of the various functional feeding groups at various stations varied significantly. The present study indicated that the land use patterns in the catchment region of the Barna sub-basin were primarily related with the most functional feeding groups being represented along the whole length of the study stretch. The effects of the functional feeding group patterns identified in the Barna sub-basin on the evaluation of ecological integrity and ecosystem functions were also investigated [26].

Biomonitoring of water bodies through Macroinvertebrates in relation to water quality

The earlier study included sampling of macro-invertebrates identified up to family level and the collecting of water samples. The physicochemical and biological analysis approach was based on scientific guides. Macroinvertebrates from 15 families of the mollusca, odonata, coleoptera, ephemeroptera, trichoptera, hemiptera, diptera, and annelida groups, found in various compositions, were gathered from six distinct stations during the current inquiry. According to the results, all of the stations that were evaluated for their water quality using NEPBIOS and NSFWQI fell within the range of water quality classes III to IV [27].

Benthic Community structure

The physicochemical characteristics and benthic diversity of the Barna stream network were assessed in the current study. The Shannon-Wiener diversity index, Simpson's index, and Margalef's richness index were used to compute the annual species diversity. pH, TDS, conductivity, DO, chloride, nitrate, phosphate, and other water quality indicators were measured. Benthic macroinvertebrates from all the sites were identified during the investigation, and they belonged to 70 taxa, 12 orders, and 41 families. For arthropods, the dominant species were *Baetis* sp., *Chironomous* sp., and *Cordulegaster boltonii*; for molluscs, the dominant species were *Lamellidens* sp., *Bellamya bengalensis*, *Indoplanorbis exustus*, and Thiara lineata; and for annelids, the dominant species were *Lumbricillus* sp., Tubifex sp. The benthic community structure varied significantly depending on the physicochemical components at different locations. Additionally, the six stations are divided into clusters via a cluster analysis that takes physical and biological characteristics into account, revealing that the grouped stations' ecological conditions are comparable. The findings of this study can be applied to a bio assessment and conservation programme for the network of streams in Barna [28].

Dam Rehabilitation and Improvement Project

The study provides details of work required and carried our for the Barna reservoir, repair and maintenance of the work was carried. The had a persistent issue with excessive seepage through the body of the dam. However, the 1981 saw the completion of the first significant treatment for preventing seepage through the dam's body. Following that, numerous further corrective actions to stop the seepage were taken periodically. Below is a brief description of such work [29].

Species diversity and assemblage of fish fauna of jamner stream

The study's goal was to investigate the fish population of the Jamner River. Four sampling locations were chosen for the investigation: Harangaon, Jeeyagaon, Sindalpur Bridge, and the Confluence Point of the Narmada River. There are a total of 27 fish species, which were classified into 16 genera, nine families, and four orders. There are 21 species of Cypriniformes, three Ophiocephaliformes, two Perciformes, and one Mastacembeliformes species that have been identified. The Ophiocephalidae family is subdominant to the dominant Cyprinidae family. The fish species known as "Mahasheer" or "Tor tor" has recently been designated as the state fish of Madhya Pradesh. The Jamner River's fish diversity is most at risk from overfishing and pollution [30].

Fish Assemblage and distribution in Barna tributaries

At Barna stream network 33 fish species are known to exist, and they are spread among 5 orders, 9 families, and 21 genera, according to the findings of the current inquiry. There were 24 species in the order Cypriniformes, which was found to be dominant. Perciformes, Ophiocephaliformes, Mastacembeliformes, and Beloniformes each had three species (1 species). With the aid of the software PAST, the species diversity was examined using the Simpson dominance index (D), Simpson index of diversity (1-D), Shannon-Weiner index (H), Evenness index, and Margalef index (Pale ontological Statistics Software Package for Education and Data Analysis). Cyprinidae, with 250 individuals (75%) and Cobitidae, with 32 individuals (10%), was the most numerous family. At the sampling site - V, the Simpson index of diversity (1-D), Shannon-Weiner index (H), and Margalef index all displayed higher values (Chamarsil) [31].

Ecological quality of Riparian habitat of Barna stream network through QBR

The goal of the current study was to use the QBR index to evaluate the ecological health of the riparian habitat along

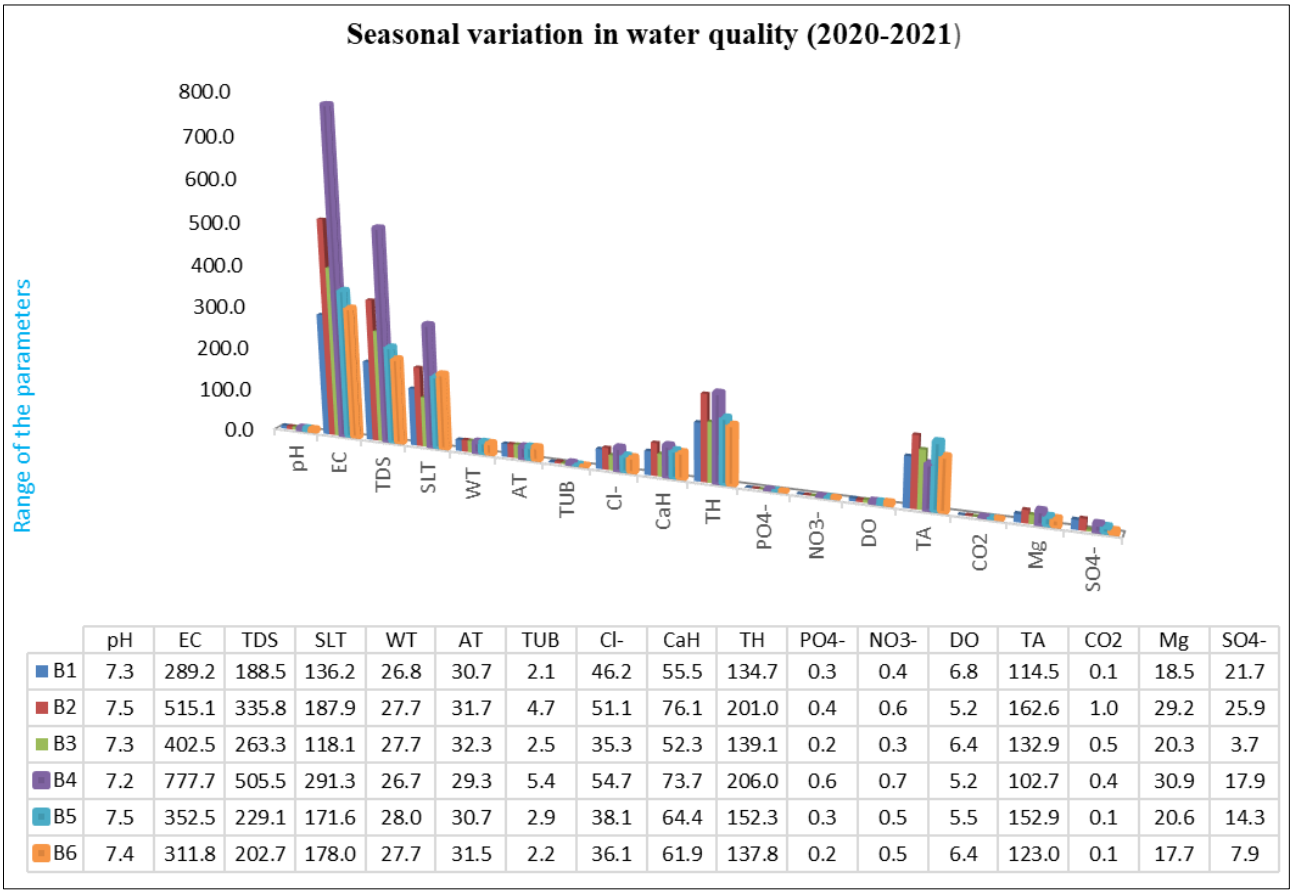
streams in the Narmada river basin. The Barna and Jamner streams' riparian habitat quality is assessed using the QBR index [32].

The left and right banks of the streams were used for the quick survey. The results showed that Jamner stream had poor riparian quality due to anthropogenic pressure and fewer vegetation along the banks, degrading the quality of riparian habitat, while Barna stream had fair riparian quality due to the presence of a considerable number of trees on both sides [32].

Morphopmetric Analysis of watershed at Barna reservoir

In this work, the five sub-watersheds of the Barna watersheds, which are located in the Raisen district of Madhya Pradesh, India, are subjected to morphometric analysis and prioritisation utilising remote sensing and GIS techniques. The morphometric factors taken into account for Stream length, bifurcation ratio, drainage density, stream frequency, texture ratio, length of overland flow, and morphology are all considered in the analysis. elongation, compactness, factor, and circulatory ratios. There is limited Parallel & Radial drainage in the Barna watershed. but primarily a pattern of dendritic drainage. For the sub-watershed No. 5D4A2b, the bifurcation ratio might reach a maximum value of 3. 000. The all of sub-watersheds' bifurcation ratios range from 1. 795 to 3. 000, indicating that lower Rb values are the characteristics of a watershed with less structural disturbance and a straight drainage pattern. The maximum values of the circulation ratio (0. 4108), elongation ratio (0. 6257), and form factor (0. 3073) are all found in the sub-watershed No. 5D4A2b. The form factor values are in the range of 0. 2662 to 0. 3073, indicating that the basin is elongated and has a flatter peak flow for a longer duration than a circular basin, which makes managing the flood easier. For each of the five sub-watersheds, the priority ranks for the compound parameters are determined. Priority is given to the sub-watershed with the lowest compound factor. In order to prevent maximum soil erosion in the sub-watershed No. 5D4A2b, which has a minimum compound factor of 2. 4, must be implemented [33].

Present status on river water quality



	pH	EC	TDS	SLT	WT	AT	TUB	Cl-	CaH	TH	PO4-	NO3-	DO	TA	CO2	Mg	SO4-
B1	7.3	289.2	188.5	136.2	26.8	30.7	2.1	46.2	55.5	134.7	0.3	0.4	6.8	114.5	0.1	18.5	21.7
B2	7.5	515.1	335.8	187.9	27.7	31.7	4.7	51.1	76.1	201.0	0.4	0.6	5.2	162.6	1.0	29.2	25.9
B3	7.3	402.5	263.3	118.1	27.7	32.3	2.5	35.3	52.3	139.1	0.2	0.3	6.4	132.9	0.5	20.3	3.7
B4	7.2	777.7	505.5	291.3	26.7	29.3	5.4	54.7	73.7	206.0	0.6	0.7	5.2	102.7	0.4	30.9	17.9
B5	7.5	352.5	229.1	171.6	28.0	30.7	2.9	38.1	64.4	152.3	0.3	0.5	5.5	152.9	0.1	20.6	14.3
B6	7.4	311.8	202.7	178.0	27.7	31.5	2.2	36.1	61.9	137.8	0.2	0.5	6.4	123.0	0.1	17.7	7.9

Site /Test	Mean /SD	pH	EC	TDS	SLT	WT	AT	TUB	Cl-	CaH	TH	PO4-	NO3-	DO	TA	CO2	Mg	SO4-
B1	Mean	7. 3	289. 2	188. 5	136. 2	26. 8	30. 7	2. 1	46. 2	55. 5	134. 7	0. 3	0. 4	6. 8	114. 5	0. 1	18. 5	21. 7
B1	Sd	0. 2	52. 7	34. 4	21. 9	4. 9	6. 8	1. 2	6. 1	16. 2	27. 0	0. 1	0. 1	0. 6	22. 1	0. 0	7. 3	0. 9
B2	Mean	7. 5	515. 1	335. 8	187. 9	27. 7	31. 7	4. 7	51. 1	76. 1	201. 0	0. 4	0. 6	5. 2	162. 6	1. 0	29. 2	25. 9
B2	Sd	0. 5	82. 0	54. 4	42. 2	4. 7	5. 7	1. 3	6. 7	25. 8	35. 4	0. 2	0. 1	0. 9	45. 7	1. 7	5. 8	1. 5
B3	Mean	7. 3	402. 5	263. 3	118. 1	27. 7	32. 3	2. 5	35. 3	52. 3	139. 1	0. 2	0. 3	6. 4	132. 9	0. 5	20. 3	3. 7
B3	Sd	0. 2	78. 4	51. 4	29. 1	4. 7	5. 7	0. 7	3. 6	15. 6	38. 3	0. 1	0. 1	0. 8	76. 9	0. 7	8. 7	0. 7
B4	Mean	7. 2	777. 7	505. 5	291. 3	26. 7	29. 3	5. 4	54. 7	73. 7	206. 0	0. 6	0. 7	5. 2	102. 7	0. 4	30. 9	17. 9
B4	Sd	0. 2	219. 9	142. 9	114. 7	4. 5	6. 5	1. 0	11. 2	10. 3	24. 2	0. 1	0. 1	0. 9	40. 6	0. 2	6. 2	8. 7
B5	Mean	7. 5	352. 5	229. 1	171. 6	28. 0	30. 7	2. 9	38. 1	64. 4	152. 3	0. 3	0. 5	5. 5	152. 9	0. 1	20. 6	14. 3

B5	Sd	0. 2	51. 5	33. 5	39. 2	4. 3	5. 0	1. 1	11. 5	16. 2	38. 6	0. 2	0. 1	0. 9	39. 0	0. 1	7. 2	0. 8
B6	Mean	7. 4	311. 8	202. 7	178. 0	27. 7	31. 5	2. 2	36. 1	61. 9	137. 8	0. 2	0. 5	6. 4	123. 0	0. 1	17. 7	7. 9
B6	Sd	0. 19	31. 16	20. 25	31. 71	5. 14	5. 52	0. 85	4. 34	16. 71	24. 43	0. 13	0. 16	0. 48	32. 76	0. 00	5. 03	0. 65

During the study 2020-2021 a strong correlation was observed between several parameters pH-WT (0. 83), pH-TA (0. 88), EC-TDS(0. 98), EC-SLT (0. 87), EC-TUB(0. 93), EC-TH(00. 89), EC-OPO^{4-} (0. 92), EC-NO^{-3}(0. 83), EC-Mg(0. 92), TDS-Slt (0. 87), TDS-TUB(0. 93), TDS-Cl (0. 75), TDS-CaH(0. 70), TDS-TH(0. 89), TDS-NO3(0. 83), TDS-Mg(0. 92), SLT-TUB(0. 93), SLT-Cl (0. 7), Slt -CaH (0. 79), Slt -TH(0. 80), Slt - NO^{-3} (0. 93), WT-TA(0. 81), CL-CaH(0. 73), CL-CAH(0. 83),CL-OPO(0. 92), CL-NO-3(0. 84),CL-SO-4(0. 82), TH-OPO^{-4} & NO^{-3} (0. 93), TH-MG(0. 9). Other parameters which showed negative correlation includes EC-DO (-0. 7),WT-EC (-0. 4), TDS-DO(-0. 74), SLT-AT(-0. 8), SLT-DO(0. 73), WT-CL(-0. 68), AT-PO4(-0. 73), AT-NO3(-0. 70), TUB-DO(-0. 89),TUB-MG(-0. 9), CAH-DO(-0. 91), TH-DO(-0. 9), PO4-DO(-0. 74), NO3-DO(-0. 86), DO-Mg (-0. 85).

Table 2: Showing Correlation between different parameters

	pH	*EC*	*TDS*	*SLT*	*WT*	*AT*	*TUB*	*Cl-*	*CaH*	*TH*	*PO4-*	*NO3-*	*DO*	*TA*	*CO2*	*Mg*	*SO4-*	*Fe*	*Fl*
pH	1. 00																		
EC	-0. 39	1																	
TDS	-0. 39	0. 98	1																
SLT	-0. 24	0. 87	0. 87	1															
WT	0. 83	-0. 49	-0. 49	-0. 46	1														
AT	0. 47	-0. 60	-0. 59	-0. 80	0. 68	1													
TUB	-0. 07	0. 93	0. 93	0. 84	-0. 32	-0. 52	1												
Cl-	-0. 27	0. 75	0. 75	0. 70	-0. 68	-0. 63	0. 82	1											
CaH	0. 30	0. 70	0. 70	0. 79	-0. 09	-0. 44	0. 89	0. 73	1										
TH	0. 01	0. 89	0. 89	0. 80	-0. 28	-0. 46	0. 99	0. 83	0. 92	1									
PO4-	-0. 26	0. 92	0. 92	0. 89	-0. 56	-0. 73	0. 95	0. 92	0. 83	0. 93	1								
NO3-	-0. 01	0. 83	0. 83	0. 93	-0. 37	-0. 70	0. 93	0. 84	0. 94	0. 93	0. 95	1							
DO	-0. 29	-0. 74	-0. 74	-0. 73	-0. 07	0. 41	-0. 89	-0. 57	-0. 91	-0. 89	-0. 78	-0. 86	1						
TA	0. 88	-0. 27	-0. 27	-0. 36	0. 81	0. 57	0. 02	-0. 21	0. 23	0. 10	-0. 21	-0. 07	-0. 35	1					
CO2	0. 23	0. 48	0. 48	0. 14	0. 10	0. 30	0. 63	0. 46	0. 53	0. 68	0. 43	0. 37	-0. 53	0. 49	1				
Mg	-0. 10	0. 92	0. 92	0. 77	-0. 34	-0. 45	0. 99	0. 84	0. 85	0. 99	0. 94	0. 88	-0. 85	0. 04	0. 71	1			
SO4-	0. 16	0. 28	0. 28	0. 33	-0. 37	-0. 39	0. 52	0. 82	0. 63	0. 59	0. 60	0. 61	-0. 43	0. 18	0. 38	0. 54	1		
Fe	0. 45	0. 11	0. 11	0. 12	0. 62	0. 43	0. 13	-0. 36	0. 25	0. 14	-0. 11	0. 05	-0. 29	0. 33	0. 30	0. 10	-0. 49	1	
Fl	0. 65	0. 05	0. 05	-0. 16	0. 43	0. 46	0. 35	0. 24	0. 45	0. 44	0. 14	0. 19	-0. 44	0. 84	0. 84	0. 41	0. 50	0. 20	1

Table 3: Showing WQI at Barna and its tributaries in different seasons (20-21)

Stations	Summer		pre-monsoon		Monsoon		Post Monsoon		Winter	
	WQI	Status	WQI	Status	WQI	Status	WQI	Status	WQI	Status
B1	44. 5	Good	40. 3	Good	32. 3	Good	33. 6	Good	22. 9	Good
B2	57. 5	poor	61. 1	poor	48. 0	Good	55. 0	poor	47. 7	Good
B3	33. 0	Good	35. 6	Good	27. 0	Good	32. 2	Good	29. 9	Good
B4	65. 0	poor	67. 5	Good	61. 4	poor	64. 5	poor	55. 5	poor
B5	49. 0	poor	52. 0	Good	32. 2	poor	31. 5	Good	33. 0	Good
B6	42. 1	Good	42. 0	Good	32. 1	Good	22. 7	Good	27. 1	Good
B1- Barna, B2-Satdhar, B3- Jamner, B4-Palakmati, B5- Chamarsil, B6 -Narheri										

All the above parameters were in permissible limits except for Palakmati river which showed an increase in Electrical conductivity and other related parameters. The satdhar river was also found to be in fair condition with some anthropogenic activities near the river. The details of the same are discuss in details in other papers.

Conclusion and Recommendation

In conclusion, the surface water from selected sites of Barna stream network is good showing healthy ecological conditions. Stream Palakmati requires a good management near Sultanpur area due to sewer loads being discharged into the river. During the study period at Satdhar substream the water quality was affected due to the agricultural activities in winter and other season. Among all other substream Narheri was found not affected by anthropogenic disturbances and Barna was also to the some extent showed no higher sources of disturbances. It is recommended that the Palakmati drain and other drains which are released directly into the river should be pre-treated for the removal of pollutants or natural treatment including some cheaper technologies may be employed for Palakmati. The Barna stream network was also affected with agricultural activities so farmers and villagers may be awared about the harmful chemicals and pesticides use may endanger the water body and motivate them to go for organic farming. The overall water quality assessment of selected sites of Barna stream network showed that most of the parameters are within the level of pollution recommended as by WHO for water quality. All of the values are well within the permissible limits, according to the research.

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