

In compliance of the Hon'ble NGT order in Execution Application No.38/2022 (In Original Application No.165/2021) dated 30.04.2024, it is most respectfully submitted here with:

1. The Hon'ble Tribunal directed to file the report in terms of the observations/ directions contained in the order, dated 30.01.2024. It is in that respect submitted:
  - 1.1 The elevated boundary wall was constructed to support the steel fencing surrounding Laxmi Taal. The purpose of the said steel fencing was to ensure that the lake and water in it is not polluted with any waste being thrown in it as well as to avoid any kind of encroachment in the future.
  - 1.2 It is further submitted that in order to allow unhindered flow of water from the catchment area, 62 holes measuring 300mm x 230mm were made every 40 meters. As the said holes have been made every 40 meters hence the flow of water is not hindered in case of flooding. **Photographs are attached as Annex 1.**
2. It is also humbly submitted that a pathway has been made over the bund of the lake. During desiltation of the lake, excavated soil was used to create a bund around the pond. To reinforce this bund and to avoid any further siltation of the lake, a pathway was created which serves dual purpose of community participation as well as the enforcement of the bund. It is humbly submitted that the redevelopment plan of Laxmi Taal was placed before Hon'ble NGT which has been taken on record in the order in Original Application No. 165/2021 dated 25.01.2022. **Before and after photographs are enclosed as Annex 2, 3 and 4.**
3. In order to restore water in the lake 4 MLD of treated water is being discharged in Laxmi Taal from the 26 MLD STP. No

untreated water is being discharged in the lake. The report of the surface water quality of the pond and outlet of 4 MLD tertiary treatment plant was submitted as part of the Report submitted before Hon'ble NGT in compliance with Execution Application No. 38/2022 (In Original Application No. 165 of 2021) dated 10.10.2023. The outlet water of 4 MLD on testing was found to be within the parameters and limit specified by the MOEF&CC. In respect of the surface water of Laxmi Taal, total and fecal coliform levels in the surface water of Laxmi Taal were measured at 14,000 MPN/100 ml and 7,000 MPN/100 ml, respectively as per the UPPCB report dated 02nd Feb, 2024. It may be noted that as per CPCB Envis (2012) report the average fecal coliform in Laxmi Pond water was recorded at 18000MPN/100ml which was much higher than the current level. However, it is to be noted that pond water is not meant for drinking purposes. **A copy of the analysis report of the 4 MLD outlet water, surface water, and CPCB Envis (2012) report of the lake is enclosed as Annex 5, 6, 7 and 8.**


4. That regarding the nature of the construction raised in the middle of the pond it is humbly submitted that the raised structure (Central Island) has been made with statue of Rani Lakshmi Bai of Jhansi. Since Laxmi Taal has been named after Rani Lakshmi Bai since historic times, it was made in commemoration of the legendary freedom fighter. It aimed to inculcate a sense of pride among the citizens of Jhansi for the protection of the lake. It is humbly submitted that the redevelopment plan of Laxmi Taal was placed before the Hon'ble Tribunal which has been taken on record in the order in Original Application No.165 of 2021 dated 25.01.2022. The said structure is raised on the pillars which does not affect the flow of water below it. **Photographs of the Central Island is enclosed as Annex 9.**

5. Regarding the original size of the pond, it is submitted that as per Khasra/ Kahtauni, the pond area including the catchment area is 33.068 Hectares and the present total area of the pond area including the catchment area is 33.068 Hectares hence there is no encroachment. **Google Imagery of the Pond including the catchment area is enclosed as Annex 10.**
6. It is most humbly submitted that as per the order of the Hon'ble NGT Court dated 03.01.2024, the report of the five-member internal committee constituted by the undersigned was considered inadequate. In order to comply with the directions of Hon'ble NGT, the undersigned requested the District Magistrate to form a committee in order to get a wholistic view and to find out any further scope of improvement. Thus the ten members committee was formed by the District Magistrate at the request of the undersigned; engaging the best possible experts available in the Jhansi district. **Ten-member committee approval is attached as Annex 11.** The water experts mentioned in the report are from Bundelkhand University which are as follows:
- a. Prof. M. M. Singh, Professor, Institute of Earth Science (Department of Geology), Bundelkhand University, Jhansi
- b. Prof. S.P. Singh, Professor and Head, Institute of Earth Science (Department of Geology) Bundelkhand University, Jhansi
- Research Paper by water experts are enclosed as Annex 12.**
7. It is again most humbly submitted that Municipal Corporation Jhansi and Smart City Jhansi is fully committed to the rejuvenation of Laxmi Taal. The renovation project of Laxmi Taal was undertaken by Jhansi Smart City Limited with the sole intention of protection and rejuvenation of this historic lake.



8. Jhansi Municipal Corporation is planting 1000 bird/environment friendly trees like Peepal, Pakad, Banyan, Jamun, Mango, etc. around the entire periphery of the lake along the boundary in order to ensure holistic ecological development of the lake and the plan for the rejuvenation was submitted before Hon'ble Tribunal which has been taken on record in the order in Original Application No. 165 of 2021 dated 25.01.2022. **Photographs are attached as Annex 13.**
9. Further, Jhansi Municipal Corporation and Jhansi Smart City Limited will abide by and comply with any direction given by this Hon'ble Tribunal for the rejuvenation and protection of the lake.
10. In the order of the Hon'ble NGT order in Execution Application No.38/2022 (In Original Application No.165/2021) dated 30.04.2024 the Hon'ble NGT directed to file the report within 6 weeks. However, in preparing the report and collecting supporting documents there has been a delay for which the undersigned seeks an unconditional apology from the Hon'ble NGT and humbly requests that the delay my kindly be condoned.

Enclosure: As above

  
(Satya Prakash) नगर आयुक्त  
जहानपुर नगर निगम

Municipal Commissioner  
Jhansi Municipal Corporation  
Jhansi



**Figure: Showing 300mm x 230mm hole in the wall**

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**Figure: Showing Laxmi Taal before rejuvenation**

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Annexure 3:



**Figure: Showing preexisting bund before rejuvenation**

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**Figure: Showing pathway constructed over preexisting bund**

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Regional Laboratory

Regional Laboratory

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**U.P. POLLUTION CONTROL BOARD**  
AVAS VIKAS COLONY (EAI PURA YOJNA)  
KANPUR ROAD, JHANSI

**ANALYSIS REPORT**

- 1 Name of Effluent Generator Institute : 26 MID STP of Laxmi Tal, Jhansi.
- 2 Name of STP Representative : Mr. Dharmveer Singh(Supervisor)..
- 3 Sample collected by : A.K Sharma(SAR Arun Kumar Mishra(ASO)
- 4 Date of Sample Collection : 05-10-2023
- 5 Sampling Point : Outlet of STP(4 MID after sand and charcoal filtration)
- 6 Sample Method : Grab

S.N.	Parameter's	Value	Standard Limit as per MEF and CC Notification October 2017
1	Colour	Colourless	All efforts should be made to remove colour and unpleasant odour as far as practicable.
2	Odour	Odourless	
3	pH	7.10	6.5-9.0
4	Biochemical Oxygen Demand (BOD <sub>5</sub> )	4.00	30 mg/l
5	Chemical Oxygen Demand	10.00	
6	Total Suspended Solid	100	<100 mg/l
7	Total Dissolved Solid	673.00	
8	Faecal Coliform (MPN Index/100 ml)	100	
9	Total Coliform (MPN Index/100 ml)	100	<1000

analyzed by:

*[Signature]*  
Scientific Assistant

*[Signature]*  
Assistant Scientific Officer

*[Signature]*  
Regional Officer

*[Signature]*

*[Signature]*

*[Signature]*

*[Signature]*

*[Signature]*

*[Signature]*

*[Signature]*

*[Signature]*

*[Signature]*

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*[Signature]*

बगर आयुक्त  
झाँसी नगर निगम, झाँसी



**REGIONAL LABORATORY KANPUR  
UTTAR PRADESH POLLUTION CONTROL BOARD**  
5243, Sadbhavans nagar, Awns vilas phase-3, Kalyanpur, Kanpur-17

TEST REPORT, WATER LABORATORY (SURFACE WATER)

Ref no-14549983/Kanpur Nagar/2024

Date: 02/02/2024

- 1- Sample Location: Laxmi Pond
- 2- District: Jhansi
- 3- Address: Near Narayan Bagh Jhansi
- 4- Sample Source: Pond
- 5- Type of sample: Surface Water
- 6- Sample Collected By: Rishi Kumar Kushwaha, LA
- 7- Odour: None
- 8- Quantity and Packing: MPN Bottle
- 9- Date of Sample Collection: 23/01/2024
- 10- Analysis Indented by: RO Kanpur Nagar
- 11- Date of sample receipt in Lab: 23/01/2024

Parameter	Unit	Results	Detection Range
Total Coliform, APHA 9221 24th Ed.: 2023	MPN/100 ml	14000	<1.8 MPN/100 ml & above
Fecal Coliform, APHA 9221 24th Ed.: 2023	MPN/100 ml	7000	<1.8 MPN/100 ml & above

\*Note: MPN: Presumptive

Note: 1. The results in this Report relate only to the items tested. 2. The report shall not be reproduced except in full, without the written permission of laboratory. 3. The test report pertains to the sample as received in Lab.

Barcode - NA

Analyzed by  
(Jyotima Gowtam(JRF))

Authorized by  
YOGENDRA  
RISHI KUMAR  
Yogendra Kr Dwivedi (SA)

AMIT  
MISHRA  
Regional Officer

Handwritten signatures and initials in blue ink, including names like 'Vineel' and '28'.

Handwritten signature in blue ink.

नगर आयुक्त  
डॉ. री. नगर निगम, जौरी



**REGIONAL LABORATORY JHANSI**  
**UTTAR PRADESH POLLUTION CONTROL BOARD**  
 Avas Vikas Colony, Talpura Yojna, Kanpur Road, Jhansi

TEST REPORT: WATER LABORATORY (SURFACE WATER)

Ref no-24274811/Jhansi/2024

Date: 05/02/2024

- 1- Sample Location: Laami Pond
- 2- District: Jhansi
- 3- Address: Near Narayan Bagh Jhansi
- 4- Sample Source: Pond
- 5- Type of sample : Surface Water
- 6- Sample Collected By : Abhishek Kumar, LA
- 7- Odour : None
- 8- Quantity and Packing : 2 Litre Plastic Jerin, BOD Bottle
- 9- Date of Sample Collection : 04/01/2024
- 10- Analyte Indented by : RO Jhansi
- 11- Date of sample receipt in Lab : 04/01/2024

Parameter	Unit	Results	Detection Range
pH, APHA24th Ed.4500-B: 2023	-	7.19	02-12
Turbidity, APHA24th Ed 2130B	N.T.U	20	1-500NTU
Colour, APHA 24th Ed. 2120B: 2023	Hazen	Colorless	5-10000 Hazen
Conductivity, APHA 24th Ed. 2510B :2023	µS/cm	941	0.1-10000 µS/cm
Suspended Solids , APHA 24th Ed. 2540 D Total Suspended Solids dried at 103-105 °C 2023	mg/l	64.00	5.0 -10000 mg/l
Dissolved Solids, APHA 24th Ed. 2540 °C Total Dissolved Solids dried at 180 °C 2023	mg/l	753.00	5.0 -15000 mg/l
Total Solids, APHA24th Ed:2540B: 2023	mg/l	282.0	10.0 -5000 mg/l
Hardness, APHA 24th Ed. 2340 °C EDTA Titrimetric Method 2023	mg/l	180.0	10.0 -1000 mg/l
Calcium, APHA 24th Ed. 3500Ca-B:2023	mg/l	102.0	10-1000 mg/l
Magnesium, APHA 24th Ed 3500Mg B: 2023	mg/l	35.0	3.0 - 500 mg/l
Chloride, APHA24th Ed 4500-Cl- B: 2023	mg/l	72.0	20-5000 mg/l
Alkalinity, APHA 24th Ed. 2320:2023	mg/l	4.5	1.0 -1000 mg/l
BOD, APHA 24th Ed. 3 day 27 °C IS 3025 ( Part 44): 1993 Bio 2023	mg/l	11.52	4.0 -1000 mg/l
COD, APHA 24th Ed. 5220 B Open Reflux Method 2023	mg/l	6.6	0.2-14.0 mg/l
D.O. , APHA 24th Ed. 4500-OB Iodometric Method 2023	mg/l	14.0	4 - 70 °C
Temp, APHA 2530 B (2-74) 24th Edition 2023, Laboratory and field Methods	°C		

\*Haze-NABL Parameters.

Note : The results in the Test Report is for only for the items tested. The report shall not be considered except in full under the written permission of Laboratory. The test report pertains to the sample as received in Lab.

Remark: - NA

*(Handwritten signatures and initials)*

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 नगर आसुरक्त  
 झाँसी नगर निगम, झाँसी

WATER QUALITY DATA 2012 | CPCB ENVIS  
 WATER QUALITY OF LAKE & POND IN CHANDIGARH, DELHI, HARYANA, HIMACHAL PRADESH, JAMMU & KASHMIR, PUNJAB, UTTAR PRADESH & UTTARAKHAND - 2012

STATION CODE	LOCATIONS	STATE	TEMPERATURE °C			D.O. (mg/l)			pH			CONDUCTIVITY (µmhos/cm)			B.O.D. (mg/l)			NITRATE-N+ NITRITE-N (mg/l)			FECAL COLIFORM (MPN/100ml)			TOTAL COLIFORM (MPN/100ml)			
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
			> 4 mg/l			6.5-8.5			< 3 mg/l																		
WATER QUALITY CRITERIA																											
206	SUNHNA LAKE	CHANDIGARH	15	27	23	3.5	11.3	6.6	6.9	8.6	7.7	187	430	250	1	4	2.5	0	0.95	0.25							
3030	SAJAJAY LAKE	DELHI							8.3	9.4	8.9	1911	2830	2371	5	5	5										
3031	BHALSVA LAKE	DELHI							8.8	8.8	8.8	9890	9890	8680	13	13	13										
3476	LAKE NEAR IT FLYOVER	DELHI							7.7	7.7	7.7	861	861	861													
3033	SOPHNA LAKE	HARYANACPCB							8.4	8.4	8.4	155	155	155	2	2	2										
1291	GOBINDSAGAR LAKE AT BILASPUR	HIMACHAL PRADESH	9	21	15	7.4	10.8	9	6	8.4	8.2	132	259	194	0.2	0.5	0.3	0.23	0.96	0.59	46	170	97	240	920	502	
1332	PONDAM LAKE AT PONG VILLAGE	HIMACHAL PRADESH	15	28	21	6	9.5	7.4	8.2	8.9	8.6	153	2150	354	0.3	1	0.7	0.08	1.67	0.43							
1429	RENBIKA LAKE, 35 KM FROM PATNA SAHIB NORTH	HIMACHAL PRADESH	12	28	21	4.8	6	6.3	6.7	8.1	7.6	201	637	425	1.4	2.8	1.9	0.07	1.85	14.6	13	20	17	24	187	41	
2849	RIMALSAR LAKE	HIMACHAL PRADESH	9	26	18	1	4.1	1.8	7.1	8.6	7.8	1	406	220	1.6	305	261	0.78	3.6	1.37	1500	2400	2338	2400	2400		
2650	KHAZJAR LAKE	HIMACHAL PRADESH	4	23	16	5.5	14	9.4	6.3	7.2	6.8	39	363	87	0.7	52	8.9	0.31	2.04	0.83							
1309	DAL LAKE AT SRINGGAR	JAMMU & KASHMIR	6	20	14	5	7.5	6.5	7.3	7.9	7.5	135	380	201	1	4	2.4	0.34	3.26	0.91							
2736	MID POINT(MANGAR LAKE)	JAMMU & KASHMIR	14	27	19	7.4	9.4	8.4	7.2	8.2	7.7	134	281	185	2.6	12.4	5.3	0	0.71	0.46							
2736	POINT OF DISCHARGE OF WASTE WATER FROM DIFFERENT ESTABLISHMENTS NEAR NAG TEMPLE	JAMMU & KASHMIR	14	27	22	6	8.7	7	7.1	7.4	7.3	130	236	173	3.4	10	6.3	0.35	0.96	0.56							
2740	MID POINT(SURINSAR LAKE)	JAMMU & KASHMIR	15	26	20	6.4	8.5	7.2	8.2	8.5	8.3	129	184	156	20	29	24	0.31	1.43	0.8							
2741	POINT OF DISCHARGE OF WASTE WATER FROM DIFFERENT ESTABLISHMENTS	JAMMU & KASHMIR	15	26	19	6	7.8	6.6	8.2	9.1	8.4	128	187	161	14	32	22	0.44	1.41	0.9							
3262	DAL LAKE AT NIGEEN WATER INTAKE PT OF POKHRIAL WATER TREATMENT PLANT	JAMMU & KASHMIR	6	25	16	5	8.8	6.3	7.5	8.2	7.9	105	337	232	1	4	2	0.22	0.74	0.38							
1362	HARKE LAKE D/S FROM CANAL	PUNJAB	12	22	18	5.2	7	6	6.9	7.5	7.2	220	396	289	1.2	2.5	1.9	2.6	3.9	3.28	90	260	195	400	5000	1650	
1364	RAMGARH LAKE	UTTAR PRADESH	14	31	23	7.9	8.8	8.3	8.1	8.8	8.3	602	704	648	4.8	6.2	5.2	1.06	3.84	2.32	240	440	320	400	760	576	
2499	SAMARPUR JHEEL, RAEBARELI	UTTAR PRADESH	20	29	24	5	6.5	5.7	8.1	6.5	8.4	432	571	512	4.1	4.7	4.4	1	1.32	1.17	4300	7000	5980	7900	8480		
2500	MAAHLI POND, JUBAI, JALAJUN	UTTAR PRADESH	2	31	27	0	7.8	5.2	0	9.2	8.2	0	2560	2258	0	31	9.3				0	14000	7025	0	54000	46500	
2501	LAXMI POND, JHANSI	UTTAR PRADESH	16	31	27	0	2.1	0.5	7.3	7.7	7.5	946	1389	1191	36	38	37										
1362	NAINI LAKE AT NAINITAL (WATER INTAKE POINT)	UTTARAKHAND	9	16	15	6	8.4	7.3	7.1	8	7.5	310	510	401	1.4	2.6	2.1				13000	21000	18000	43000	93000	70250	
3437	BHEEMTAL LAKE	UTTARAKHAND	11	20	17	6.4	7.6	7.4	7.8	8.4	8.1	180	220	205	1.6	3	2.4										

WATER QUALITY DATA 2012



नगर आयुक्त  
झाँसी नगर निगम, झाँसी



## Annexure 11:

5A

जिलाधिकारी महोदय,

कृपया अवगत कराना है कि मा0 एन0जी0टी0 में प्रचलित वाद संख्या 33/2022 (मूल वाद संख्या 165/2021) में दिनांक 10.10.2023 को प्रस्तर संख्या 07 में निम्न आदेश पारित किया गया है "The report also contains photograph of Laxmi Tal taken at the time of spot inspection which reveals that an elevated boundary wall to support the steel fencing surrounding Laxmi Tal has been constructed. The same is likely to effect the catchment area into the Tal and may have adverse effect on the survival of the Tal. Therefore, the Commissioner, Municipal Corporation, Jhansi is directed to submit the report in respect of the construction of the elevated boundary wall and path way surrounding the buffer zone Laxmi Tal and its likely adverse effect on the Tal or expected benefits therefrom."

उक्त आदेश के अनुपालन के क्रम में दिनांक 18.10.2023 को एक 05 सदस्यीय समिति गठित की गयी थी जिसके सदस्य हैं :-

1. श्री एस0के0 सिंह, मुख्य अभियंता
2. श्री मुकेश पाल, अधिशासी अभियंता, जल निगम
3. श्री के0बी0 सिंह, नोडल हेड PMC, JSCL
4. श्रीमती देविना, प्रभारी महाप्रबंधक JSCL
5. श्री सिद्धार्थ गुप्ता, पर्यावरण अभियंता, नगर निगम, झाँसी

उक्त समिति की अनुशंसा पर मा0 एन0जी0टी0 के आदेश के अनुपालन के क्रम में मा0 एन0जी0टी0 में अनुपालन आख्या दिनांक 21.12.2023 को प्रेषित की गयी थी। दिनांक 03.01.2024 को सुनवाई के दौरान मा0 एन0जी0टी0 के द्वारा समिति में तालाब/झील/जल से सम्बद्ध विशेषज्ञ = होने पर अनुपालन आख्या को अपर्याप्त मानते हुये तालाब/झील/जल विशेषज्ञों को समिति में शामिल करते हुये पुनःविस्तृत आख्या हेतु आदेशित किया गया है।

मा0 एन0जी0टी0 की अपेक्षित आख्या के क्रम में निम्नानुसार समिति के गठन पर विचार किया जा सकता है :-

1. श्री एम0पी0 गौतम, प्रभागीय वनाधिकारी, झाँसी - अध्यक्ष
2. श्री एस0के0 सिंह, मुख्य अभियंता, नगर निगम, झाँसी। (संयोजक-सदस्य)
3. श्री उमेश कुमार, अधिशासी अभियंता, सिचाई विभाग, झाँसी। (सदस्य)
4. श्री मुकेश पाल, अधिशासी अभियंता, जल निगम, झाँसी। (सदस्य)
5. श्री ज्ञानेन्द्र सिंह, उप निदेशक मत्स्य, झाँसी। (सदस्य)
6. श्री के0बी0 सिंह, नोडल हेड PMC, JSCL (सदस्य)
7. श्री आकाशदीप, भू-मीतिकीविद, झाँसी। (सदस्य)
8. प्रो0 एस0पी0 सिंह जल विज्ञानी, बुन्देलखण्ड विश्वविद्यालय झाँसी। (सदस्य)
9. प्रो0 एम0एम0 सिंह जल विज्ञानी, बुन्देलखण्ड विश्वविद्यालय झाँसी। (सदस्य)
10. डा0 विनीत कुमार पर्यावरण विज्ञान, बुन्देलखण्ड विश्वविद्यालय झाँसी। (सदस्य)

यदि उपर्युक्त से महोदय सहमत हो तो अनुमोदन देने अथवा अन्य निर्देश देने का कष्ट करें। 05/01/2024

05/01/2024  
सहायक नगर आयुक्त  
झाँसी नगर निगम, झाँसी

05/01/2024  
जिलाधिकारी,  
झाँसी  
नगर आयुक्त  
नगर निगम, झाँसी

नगर आयुक्त  
झाँसी नगर निगम, झाँसी



# A GIS-based Approach for Morphometric Analysis of Jamini Basin and Its Subwatersheds: Implication for Conservation of Soil and Water Resources

S. C. Bhatt, Rubal Singh, Rahul Singh, Mohd Saif, and M. M. Singh

## Abstract

Jamini a tributary of Betwa River has Janrar, Onri, Sajnam, Shanzad and Baragl five subwatersheds. The quantitative morphometric analysis of its subwatersheds was carried out by using advanced techniques of remote sensing and GIS. The linear, areal and relief parameters along with hypsometric values were generated for each subwatershed of Jamini basin. The remotely sensed Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) data with a capture resolution of 3.0 arc second and pixel resolution of 30 m were used to extract the drainage map, density, contour, aspect and other maps. The mean bifurcation ratio (3.79 to 5.04) of Jamini and its all subwatersheds indicate that the drainage is structurally controlled. The Rho coefficient values reveal that the higher hydrologic storage during the flood and a decrease in the erosion during elevated discharge are observed in the basin. The drainage density (1.0 to 1.04) indicates that the basin is impermeable and shows low groundwater storage capacity in hard rock granitic terrain. The form factor (0.18 to 0.49), elongation and circulatory ratios indicate that the Jamini basin and subwatersheds are significantly elongated and show low peak flow of longer duration. The values of Ruggedness and Melton ruggedness number infer that the basin is slightly rugged and less prone to erosion and sediment transport. The S-shaped hypsometric curves show that the

basin is susceptible to moderate erosion and the hypsometric index values (0.49 to 0.50) imply that the basin has mature geomorphic terrain with moderately eroded landscapes.

## Keywords

Morphometric analysis • Hypsometry • Correlation matrix • Jamini basin • Central India

## 1 Introduction

Morphometric parameters reveal the quantitative evaluation of shape and size of landforms and characteristics of the basin (Horton 1945; Melton 1958; Strahler 1964; Miller 1953; Pareta and Pareta, 2011; Prakash et al. 2016, 2019; Bhatt et al. 2017, 2020; Bhatt 2020). It can be defined as an indicator of landform structure and hydrologic processes, erosional and physical properties of soil (Horton 1932; 1945; Strahler 1964; Smith 1950). Morphometric parameters determine the lithological and structural control on drainage and characteristics of fluvial landscapes (Pati et al. 2006; 2008; Prakash et al. 2016; 2017; Pareta and Pareta 2011; Bhatt et al. 2017, 2020). The findings of morphometric analysis give information about hydrogeologic and erosion-prone area and characters of surface and ground-water potentials of a watershed (Aparna et al. 2015).

The morphotectonic and morphometric studies of tributaries of the Ganga river have been done by several researchers (Tangri 1992; Shukla et al. 2012). Contrary to this the morphometric and morphotectonic parameters of most of the tributaries of Yamuna particularly coming from Bundelkhand craton have not been studied in detail except by few workers (Prakash et al. 2016; 2017; Pareta and Pareta 2011; 2012; Bhatt et al. 2017, 2020; Bhatt, 2020; Panda et al. 2019). Therefore, in present work, the morphometric and hypsometric analysis has been carried out to explore the

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A. K. Shandilya et al. (eds.), *Geological and Geo-Environmental Processes on Earth*, Springer Natural Hazards,  
[https://doi.org/10.1007/978-981-16-4122-0\\_16](https://doi.org/10.1007/978-981-16-4122-0_16)

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नगर आनुवंशिक  
संशोधन विभाग, जयपुर



## MORPHOMETRIC ANALYSIS OF LAKHARI RIVER

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### ABSTRACT

To examine the hydrology and morphometric analysis of Lakhari River which is a tributary of Dhasan river of Betwa river system in Bundelkhand region of Uttar-Pradesh and Madhya Pradesh. We used Geo-Informatics techniques in order to examine the hydrology and morphometric analysis. Morphometric analysis revealed that the Lakhari basin is characterized by dendritic to sub-dendritic drainage pattern. The development of stream segments in the basin area is affected by rainfall. The area has undulating terrain. The analysis shows that the total numbers as well as total length of streams segments are maximum in first order streams and decreases as the stream order increases. From the study it is clear that the morphometric analysis based on GIS techniques is very useful to understand the prevailing Geo-hydrological characteristics and for watershed planning.

**KEYWORDS :** Geo-informatics, Hydrology, Lakhari River, Dendritic, Morphometry

### INTRODUCTION

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Agarwal, 1998, Obi Reddy et al., 2002). So Morphometric analysis is referred as the quantitative evaluation of form characteristics of the earth surface and any landform unit. The composition of the stream system of a drainage basin is expressed quantitatively with stream order, drainage density, bifurcation ratio and stream length ratio Horton, 1945). It incorporates quantitative study of the various components such as, stream segments, basin length, basin parameters, basin area, altitude, of the land which indicates the nature of development of the basin. The morphometric analysis of the drainage basin and channel network play an important role to understand the Geo-hydrological behavior of drainage basin and Geomorphology etc. The relationship between various drainage parameters and aforesaid factors are well recognized by many researchers (Horton, 1945; Strahler, 1957; Melton, 1958; Pakhmode et al., 2003; and Gangalakunta, 2004). Various important hydrologic phenomena can be correlated with the physiographic characteristics of drainage basin as; size and length of the contributories etc. (Rastogi et al., 1976), relief and climate are the primary determinants of running water ecosystems functioning at the basin scale

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नगर आयुक्त  
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Impact of mining due to heavy metal pollution on groundwater resources in  
 Jhansi, Bundelkhand Region of Utter Pradesh, India.

Impacto de la minería debido a la contaminación por metales pesados en los  
 recursos de aguas subterráneas en Jhansi, región de Bundelkhand en Utter  
 Pradesh, India.

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ABSTRACT

This study evaluated potential groundwater with toxic metals in and around an abundant granite mines in Jhansi. The pH values for ground waters were neutral, with a slight increase of the values in the mining areas. Higher values of electrical conductivity were observed in the mine area. In these areas, groundwater contamination by Cd, Fe, and Pb were observed. Most of the toxic metals were decreased with distance from mines; some have decreased gradually near the adjoining residential areas which may due to mixing with metal-free waters parameters like EC, TDS, Turbidity, DO, TH were found more in mining site comparison to non-mining site.

**Key Words:** Mining; Heavy metals; Groundwater and Bundelkhand region.

RESUMEN


This study evaluated potential groundwater with toxic metals in and around an abundant granite mines in Jhansi. The pH values for ground waters were neutral, with a slight increase of the values in the mining areas. Higher values of electrical conductivity were observed in the mine area. In these areas, groundwater contamination by Cd, Fe, and Pb were observed. Most of the toxic metals were decreased with distance from mines; some have decreased gradually near the adjoining residential areas which may due to mixing with metal-free waters parameters like EC, TDS, Turbidity, DO, TH were found more in mining site comparison to non-mining site.

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INTRODUCTION

Mining affects water resources, both surface and groundwater, at various stages of life cycle of the mine and even after its closure. The mining process itself, mineral processing sing operations, mine dewatering, seepage

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Remote sensing and GIS based approach in morphometric  
 analysis of Birma river basin (Central India).

Enfoque basado en sensores remotos y SIG en el análisis  
 morfométrico de la cuenca del río Birma (India Central).

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ABSTRACT

Birma river basin lies between two states of India (Uttar Pradesh and Madhya Pradesh). The parameters of Morphometric analysis were measured as Stream Order, Drainage Density, Stream Frequency, Bifurcation Ratio, Elongation Ratio, etc. Digital Elevation Model is downloaded from the USGS website. The results show that the Basin ranges from dendritic to sub-dendritic and is heterogeneous in texture and structurally controlled. The stream order ranges from first order to sixth order and the drainage density and elongation ratio is 1.23 and 0.59 respectively which specified that the basin is elongated in shape. The bifurcation ratio varies from 2.67 to 9.0 indicating that the basin has undulating topography. The analysis is contributed to understand watershed management sites for the conservation of soil and water. Assessment of these parameters ultimately gives information for the arrangement of sustainable water resource development and its management for the local people residing nearby the river.

**Keywords:** Birma River Basin, Digital Elevation Model (DEM), Geographical Information System (GIS), Morphometric analysis, Remote Sensing.

RESUMEN

La cuenca del río Birma se encuentra entre dos estados de la India (Uttar Pradesh y Madhya Pradesh). Los parámetros del análisis morfométrico se midieron como Orden de la corriente, Densidad de drenaje, Frecuencia de la corriente, Relación de bifurcación, Relación de alargamiento, etc. El modelo de elevación digital se descarga del sitio web del USGS. Los resultados muestran que la Cuenca varía de dendrítica a subdendrítica y es heterogénea en textura y estructuralmente controlada. El orden de las corrientes varía de primer orden a

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## AHP and TOPSIS Based Sub-Watershed Prioritization and Tectonic Analysis of Ami River Basin, Uttar Pradesh

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Received: 11 February 2021/ Revised form Accepted: 26 June 2021  
 © 2022 Geological Society of India, Bengaluru, India

### ABSTRACT

Soil erosion is a major consequence which usually reduces soil productivity. The identification of its susceptible zones is essential in order to apply preventive measures in any basin. A detailed morphometric evaluation of Ami river basin is done using Shuttle Radar Topography Mission (SRTM) data of 30m resolution. Technique for order of preference by similarity to ideal solution (TOPSIS) and analytic hierarchy process (AHP) based prioritization and characterization of sub-watersheds is important to plan and manage the natural resources of a region. Total 18 sub-watersheds with an outlet having 4<sup>th</sup> order drainage were selected for the prioritization purpose for soil erosion susceptibility zones with the help of 10 morphometric parameters. The sub-watersheds were ordered from SW-I to SW-XVIII. In this regard, SW-XV has the highest priority (0.628) and higher soil erosion while SW-XVIII (0.317) has lowest conditions for soil erosion.

Various tectonic and sinuosity related parameters are calculated and analyzed like hypsometric integral (0.49), asymmetric factor (50.1) and transverse topographic symmetric factor suggesting good symmetry of basin with no tectonic tilt. The value of standard sinuosity index (1.2) suggests that Ami river is naturally sinuous stream. Morphometric parameters suggest less structurally controlled and normal category of the basin. The basin has coarse texture of drainage with highly suspect to soil erosion and high run off.

### INTRODUCTION

Soil is a naturally occurring resource and valuable for all the biotic components (Ameri et al. 2018). For its assessment, it is necessary to conduct management plans which can deal with the determination of soil erosion prone regions at macro and micro scale (Alexakis et al. 2013). Rivers are the most prominent geomorphic systems of landscape (Varma et al. 2020) which prompts morphometric change in any basin and transport of sediments in its fluvial process (Chopra et al. 2005). Morphometry based evaluation of any basin provides information about the shape (elongated or circular) and size (total area), altitude, slope and river basin characteristics (Romshoo et al. 2012). This information about river basin is useful in planning and management of water resources, soil erosion and many more (Nag and Chakraborty 2003).

RS technique with GIS is convenient tool, being commonly used on the hydrological analysis of basin. The entire basin with existing streams is delineated in GIS environment using ArcGIS software.

The plausible expression of the hydrological characteristics was first proposed by Horton (1945) through mathematical and theoretical observations. He concluded a valid number of mathematical relationships and later developed laws for the river networks (Zavoianu 1985). These laws were further revised and modified (Schumm 1956; Morisawa 1957; Melton 1958; Strahler 1964). Tectonic movement controls the drainage pattern and landform evolution (Ouchi, 1985; Radhakrishna 1992; Sinha and Roy 2001; Flores-Prieto et al. 2015; Kothiyari et al. 2019; Das 2020). Different researchers have performed morphotectonic analysis by using remote sensing and GIS technique (Bhatt et al. 2017; Bhatt et al. 2014). In tectonic geomorphology, river basin analysis is a fundamental approach for investigating and interpreting tectonics (Kothiyari et al. 2017; Yadav and Singh 2021). Drainage network indicates the local or regional tectonic framework as the river follows weak zones of rocks (fracture zones) and fault lines (Kandregula et al. 2019).

Two important methods namely TOPSIS and AHP are used in the present paper to prioritize indices. The method of AHP, initially presented by Saaty (1988), is a flexible method which is based on the hierarchical structure for determining and compiling the prioritization for logical compatibility of judgments. It is also used for solving many complex problems related to decision making (Chan and Kumar 2007; Pishyar et al. 2020). Hwang and Yoon was the first to develop TOPSIS in the year 1981.

In eighteen selected fourth order wise sub-watersheds, prioritization is done using ten morphometric parameters viz. stream frequency, texture ratio, shape factor, length of overland flow etc. These parameters help to find out the high, moderate and low soil erosion zones. For the sinuosity analysis, various indices like topographic, hydraulic and standard sinuosity indices along with valley and channel index are calculated. The present study, thus, focuses upon the analysis of soil erosion in the drainage basin with MCDM and to analyze the tectonic implications on the Ami river basin.

### STUDY AREA

Geographically, Ami river basin extends from 26°31'N to 27°15'N and 83°26'E to 83°35'E (Fig. 1). Ami river which flows

  
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