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Comprehensive Risk Analysis of Physicochemical Parameters through WQI and Temporal Variation in Sharda Canal's Surface Water, Uttar Pradesh, India

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Abstract: The study aimed to evaluate the ecological status of Sharda Canal, a major irrigation and domestic water supply source in U.P., India. Based on land use type and potential pollution sources, ten survey sites were selected from the Sharda Canal Kheri Branch having a length of 258.80 km. The analysis of the quality of water studied for pH, DO, COD, BOD, Nitrates, Sulphates, TDS, TSS, hardness, alkalinity, calcium, and magnesium were calculated as different components. The weighted arithmetic index method was applied to evaluate WQI. As a result, the pollutant load was significantly different between the locations. On the other hand, the water quality index at Sharda Barrage in Lakhimpur Kheri was 110.29. At the same time, it stood at 128 on Bakshi ka talab distributary in Lucknow which is from upstream to downstream. The observed high values of TDS, COD, sulfates, and nitrates were indicative of the likely presence of pollutants that can have a severe influence on local water quality and aquatic ecology. In summary, the outcomes of this assessment have drawn vivid and clearer boundaries to register an actual integrated action which is urgently needed otherwise premature water quality deterioration in the Sharda Canal will be a fact. Hence, the water quality variables that work in Sharda Canal have been assessed by a considerable amount of WQI, an integrated physicochemical appraisal tool to accomplish a precise comprehension. These may include improving industrial and agricultural regulations and practices, increasing treatment plant efficiency, raising awareness among public officials and the general public, and reducing point-source pollution.

Keywords: Water Quality Index (WQI); Sharda Canal; Physicochemical properties; Pollution sources; Uttar Pradesh; Water resource management.

I. INTRODUCTION

Water is a widespread life-supporting resource on earth so water quality has been essential to human and environmental health. The issues of contaminated and scarce water are being faced by people around the globe. Only 3% of the water in the world is consumable and fresh [1–3]. However, it is among the most polluted because of agriculture, industry, and human waste, which is a menace to human health and the environment. Thus, water without due purification is seeping through pollution or directly to residual water resources, causing harm by this discharge of toxic compounds[4][5].

Anything that changes the chemical, physical, or biological makeup of water in a way that harms living things makes it polluted water. In addition to being a basic necessity of human

existence, water is an essential component of the natural world, and is the cornerstone in agriculture, industry, and finance[6, 7]. Best management plans can greatly reduce liquid manure applications, helping to reduce pollution from land spreading of manure from concentrated animal feeding operations, but agricultural runoff remains one of the lead sources of worldwide water pollution. It is a useful and simple way to communicate results to our community using specific characteristics found in water quality and to make decisions on water usage. The WQI classifies potable water based on the quality of water determined in the field[8].

While traditional techniques are based on the analysis of some parameters, their limitations are revealed in the inability to create a full picture of water quality. Such methods are focused on pollutants separately, which creates a difficult of

understatement the cumulative effect of several factors that may result in water pollution. In addition, a lack of a common strategy on how to integrate and interpret the multiple parameters makes complicated communication between professionals and decision-making. In such a case, the Water Quality Index methodology, which makes it possible to get an across-the-board probe of diverse factors, seems valuable [9].

This study takes the WQI method for various reasons that rationalize the choice of such a technique. First, WQI enables a more thorough determination of the water quality status as it provides an opportunity to evaluate several parameters simultaneously. The alternative would be to determine the quality directly based on one or more individual factors. Second, the WQI method also allows various categorizations of water quality, making it easier to estimate pollution and develop scientific ways of counteraction. Finally, this method is well-known and broadly accepted and allows this study to compare with other research results and water quality criteria [10, 11].

Considering the peculiar location of the Sharda Canal, which is presented based on its specific points, it is evident that paying attention to physicochemical properties is critical[12]. Therefore, this study seeks to estimate hydrologically relevant parameters to determine their variation apply proper measures to diminish their sources, and develop strategies for water quality improvement. Additionally, when the WQI system is a comprehensive approach to analyzing water quality, it faces multiple limitations, and solutions to overcome these challenges have to be considered. Various physicochemical properties can be considered in reporting water quality in the Sharda Canal given the specificity of the Site. This study is expected to help in the identification of hydrological complexes and temporal distinct of hydrological parameters by comparison of various canal sections mitigation of pollution sources and formulation of water treatment plans. Similarly, the study has also contributed to different regions of study to extend the WQI to the Sharda Canal [13].

However, in addition to its being one of the more complete applications of the quality of water, it is also important not to forget the limitation of material work done to overcome problems faced by the used there is an inherent problem with this method which is about perceptions, that when choosing parameters and assigning weights to them[14]; different research could choose the different parameters publish different weights factors, and then it may be difficult to evaluate the entire reaction at all water samples. As addressed by the research paper - the problem is supposed to be resolved, if it has an inevitable status - the solution encouraged the comprehensive justification of the dimensions and weight, that are partly performed according to the conventional directives and previous practices of these types of canals[15].

The research gap will be filled through a systematic consideration of water quality in the Sharda Canal. After covering this gap, the study would have achieved a profound understanding of the quality of water in the canal. It would then be easier to develop water resources management plans and

make informed decisions based on well-reasoned and unbiased information.

The weighted arithmetic index method used in this study is different from conventional WQI approaches similar to the CCME, NSF and Oregon methods. Arguments have been made for evaluating the importance of guideline exceedances, with CCME (using both frequency and magnitude) while NSF uses fixed parameters defined by weighting curve, however without flexibility in customizing these weights. This approach is particularly useful for the Sharda Canal study as it can account for certain site-specific conditions and avoids homogenization of various appropriate factors. But it is likely less affected by outliers in data than the Oregon WQI. The selection of method can have important repercussions in WQI values and consequently different interpretations implying the necessary to carefully choose a measurement method when assessing water quality.

The weighted arithmetic aggregation method of WQI was employed to demarcate the categories of constituents for the mathematical quality of water in the Sharda Canal. It managed to bypass the aforementioned limitation with the use of scientifically proven methodologies thereby unearthing way deeper insights into the water quality of the Sharda canal. So the production of comprehensive works by other workers will, as a consequence, aid the establishment of effective water management strategies, that will be supported by empirical data and the actual conditions of the irrigation activities for an industry and large-scale crop yield (e.g. wheat, sugarcane) in the study area under consideration[12].

The study aims to study the seasonal changes that is the temporal variation [16]of most of the critical physicochemical and biological pollutants in various sections of the Sharda Canal and help find potential strategies to protect water quality in different regions[12]. During the study, water samples will be divided into different quality types and the measurement of parameter concentration. The temporal analysis using the ArcGIS method and the plotting of the model through ArcMap to analyze water quality in various regions to help control pollution and manage water within region water resources for sustainable development[17].

II. MATERIALS AND METHODS

Study Area

The study encompasses the entire 258.80-kilometer length of the Kheri Branch of the Sharda Canal, an essential irrigation and domestic water supply canal that gushes out from the Sharda River situated in the State of Uttar Pradesh, India[12]. The canal flows through the interstate geographical ecosystem comprising urban, industrial, and agrarian landscapes across three districts, namely Lakhimpur Kheri, Sitapur, and Lucknow. Given the proximity to urban water bodies and industrial agglomeration in the agricultural drop areas, such as Lakhimpur Kheri, Sitapur, and Lucknow, the study represents a risk of anthropogenic signature on the water quality.

1. Sharda Barrage, Lakhimpur Kheri (28.1621 latitude and 81.0458 longitude)
2. Aliganj, Lakhimpur Kheri (28.1006 latitude and 80.5800 longitude)
3. Phardhan, Lakhimpur Kheri (27.5901 latitude and 80.3923 longitude)
4. Haargaon, Sitapur (27.4927 latitude and 80.4422 longitude)
5. Maanpur, Sitapur (27.3055 latitude and 80.5230 longitude)
6. Kamlapur, Sitapur (27.3862 latitude and 80.8181 longitude)
7. Sidhauri, Sitapur (27.2821 latitude and 80.8344 longitude)
8. Ataria, Sitapur (27.1665 latitude and 80.8682 longitude)
9. Itaunja, Lucknow (27.0808 latitude and 80.8959 longitude)
10. Bakshi Ka Talab, Lucknow (27.0118 latitude and 80.5531 longitude)

Sampling Locations

The sampling points along the Sharda Canal Fig 1 were selected strategically and mapped using the Geographic Information System software. The canal was arbitrarily segmented based on the presence of urban areas industrial activities and agricultural activities. Eventually, ten sites were selected to cover the 258.90 km length of the canal which includes three samples from Lakhimpur Kheri district, five samples from Sitapur district, and two samples from Lucknow district. These sampling points aimed to represent the variability in the water quality resulting from land uses and other human inputs. The sampling point was selected at the source of water, Sharda barrage, to represent the untouched water quality in the Sharda. Then the subsequent points were identified downstream, covering an urban sentiment in which the industrial cluster includes Haargaon and Maanpur in the Sitapur district whereas the intensive agricultural pattern included Phardhan in the Lakhimpur Kheri district and Kamlapur in the Sitapur district.

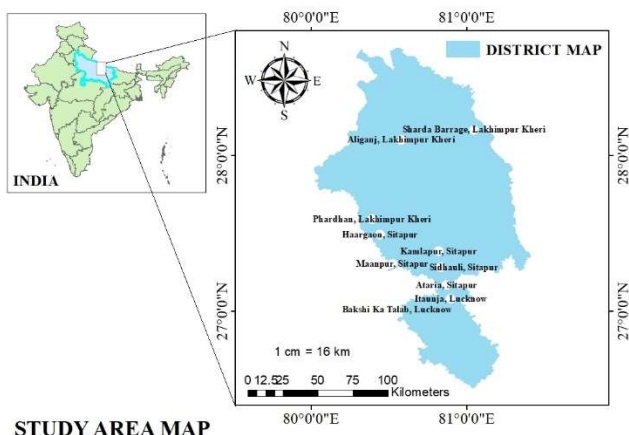


Fig. 1: Study Area Map

Analytical Technique used in the WQI Model

The WQI was obtained by a model structure that involved four steps. Twelve physicochemical parameters were recognized for quality assessment, immediately it is followed by pH, DO(Dissolved Oxygen), COD(Chemical Oxygen Demand), BOD(Biological oxygen demand) nitrates, sulphates, TDS(Total dissolved Solids, TSS(Total suspended solids.), total hardness, alkalinity, calcium and magnesium. As a second step, the concentrations of these parameters in each sample were converted into dimensionless sub-indices. The third layer was weighting the parameters to measure their importance in overall water quality assessment. Finally, a suitable aggregation function was used to aggregate the sub-indices with associated weights and determine universal WQI. The obtained WQI value was then compared with a pre-determined classification scale for water quality. This structured methodology had the advantage of a thorough assessment that included several variables and their weights.

A typical WQI model structure is presented in the following four primary steps[18]:

1. Identifying the parameters – one or more quality parameters are selected for quality assessment.
2. Conversion of concentrations – the quality parameter concentrations are converted into sub-indices dimensionless.
3. Assigning parameter weightage – each parameter is allocated a weightage quantifying its importance in quality assessment.
4. Calculation of the overall index – using the weights, appropriate aggregation function, and rating scale the sub-indices are combined into the overall index. The quality is categorized using the rating scale based on the WQI value.

Water Quality Index (WQI) Calculation

The Water Quality Index (WQI) of the Sharda Canal was calculated using the weighted arithmetic index method[19]

$$WQI = \frac{\sum(q_n \times W_n)}{\sum W_n} \dots \dots \dots (1)$$

First, the unit weight (W_n) for all the selected physicochemical parameters was calculated using the equation:

$$W_n = K / S_n \dots \dots \dots (2)$$

Where: W_n is the Unit weight for the nth parameter S_n is the standard permissible value of the nth parameter K is the Proportionality constant derived using the equation:

$$K = [1 / (\sum(1/S_n))] \dots \dots \dots (3)$$

In the second step, a quality rating (q_n) for each parameter was calculated using the equation:

$$q_n = [(V_n - V_{ideal}) / (S_n - V_{ideal})] \times 100 \dots \dots \dots (4)$$

Where, V_n = Measured value of the nth parameter; V_i = ideal value of the nth parameter (standard permissible limit and ideal values of water were as per BIS 2012)[18, 20].

Parameter Selection

The selection of parameters for the WQI model many times done by convenience and ease, such as data availability, expert opinions, and the environmental importance of a particular water quality parameter. Most of the WQI models used only the fundamental water quality parameters because of the non-availability of measured data for the remaining parameters. The parameter lists in Table 1 models were sometimes altered by many researchers based on data accessibility and obtainability. Sometimes, the significant water quality parameters might not be incorporated in the model since enough data were not obtainable. Selection of multiple parameters enabled including a wide array of physicochemical properties to provide insight into the Sharda Canal water quality and potential sources of contamination. As noted by NURP (Nationwide Urban Runoff Program)[21], the choice of parameters was based on established monitoring standards and was intended to create an extensive overview of the canal's water quality. Specifically, the selected parameters made it possible to identify potential contaminants, assess the ability of the water for use in multiple applications, including irrigation, and suggest effective management strategies.

TABLE 1

The following Table Outlines the Parameters Analyzed in this Study

Parameters	Range (IS 10500) (in mg L ⁻¹)	Significance of Irrigation
pH	6.5 to 8.5	Influences nutrient availability and soil structure. The optimal range is 6-8.
Dissolved Oxygen (DO)	5.0 to 8.0	Essential for root respiration and microbial activity.
Biochemical Oxygen Demand (BOD)	2 to 30	Indicates organic pollution. High BOD can deplete DO.
Chemical Oxygen Demand (COD)	10 to 250	Measures total organic and inorganic pollutants.
Total Suspended Solids (TSS)	10 to 50	Can clog irrigation systems and reduce water penetration.
Total Dissolved Solids (TDS)	500 (max)	High TDS may affect soil structure and plant growth.
Alkalinity	200 (max as CaCO ₃)	Affects pH stability. High alkalinity may lead to scale formation.
Calcium	75(max)	Important for soil structure, deficiency can affect plant growth.
Magnesium	30(max)	Necessary for chlorophyll synthesis and photosynthesis.
Total Hardness	300 (max as CaCO ₃)	Presence of calcium and magnesium. Affects soil permeability.
Nitrates	45 (max as NO ₃)	Essential nutrient but high levels may lead to toxicity.
Sulfates	200 (max as SO ₄)	High levels can lead to soil acidity and toxicity.

III. RESULTS AND DISCUSSION

The data for the water quality index was prepared in Table 2, from where surface water physicochemical characteristics also derived significant results (see Table 2) inside a sampling site across. Four of the unique observations made are Maanpur distributary and Ataria distributary in Sitapur district whereas Itaunja distributary and Bakshi Ka Talab distributary in Lucknow district these were observed as Very Poor water sample classification as on this station there is not Viable sample was found at any other place. On the other hand, all remaining sampling sites are featured as Poor water. As a result, this could lead to the potential endangering of the water quality that is sampled elsewhere. Table 3, describes the WQI values of all sampling points and the category of water in which the sample lie concerning the respective WQI ranges in Table 4.

TABLE 2

Water Quality Parameters at The Sampling Locations Along the Sharda Canal

Sr. No.	Sample Location	WQI Values	Category of Water
1	Sharda Barrage, Lakhimpur Kheri	110.29	Poor water
2	Aliganj, Lakhimpur Kheri	111.16	Poor water
3	Phardhan, Lakhimpur Kheri	112.70	Poor water
4	Haargaon, Sitapur	115.05	Poor water
5	Maanpur, Sitapur	121.24	Very poor water
6	Kamlapur, Sitapur	117.17	Poor water
7	Sidhauli, Sitapur	118.62	Poor water
8	Ataria, Sitapur	121.57	Very poor water
9	Itaunja, Lucknow	123.93	Very poor water
10	Bakshi Ka Talab, Lucknow	128	Very poor water

Table 3

WQI Values and Water Quality Categories at the Sampling Locations

WQI Range	Category of Water
>300	Unfit for drinking purposes
120-300	Very poor water
100-120	Poor water
50-100	Good water
<50	Excellent water

Table 5 specifies the location of the samples for the graphical representation of WQI values from various locations as shown in Fig. 2, whereas Fig. Figure 3-6 describes the graphical image of the raised COD, TDS, Sulphate, and Nitrate parameters. The WQI values and high values of the parameters reveal that water quality in the Sharda Canal needs a lot of improvement. Effective ways to solve these problems could be

maintaining stringent policies for industrial and agricultural operations, improving sewage treatments at a large scale, and spreading awareness among the general public — which may decrease pollution outlets.

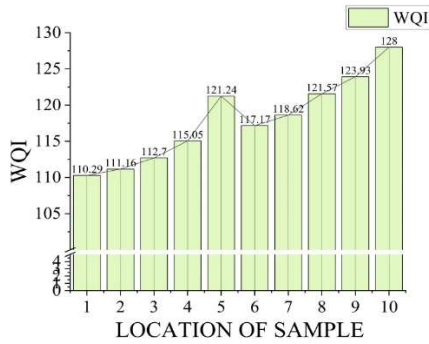


Fig. 2: Graphical Representation of WQI Values Obtained

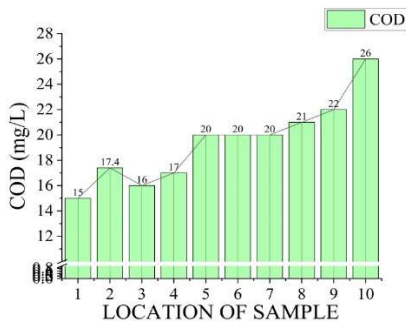


Fig. 3: Graphical Representation of Elevated COD Obtained

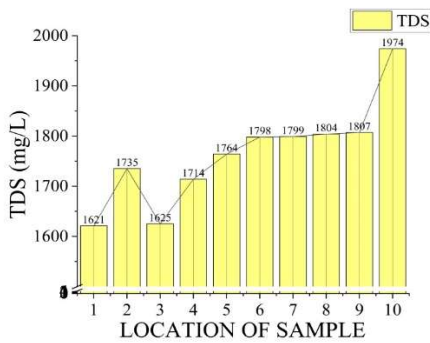


Fig. 4: Graphical Representation of Elevated TDS Obtained

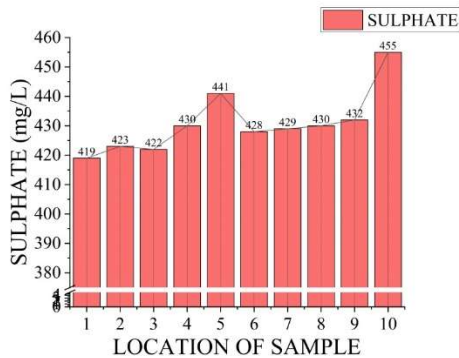


Fig. 5: Graphical Representation of Elevated Sulphate Obtained

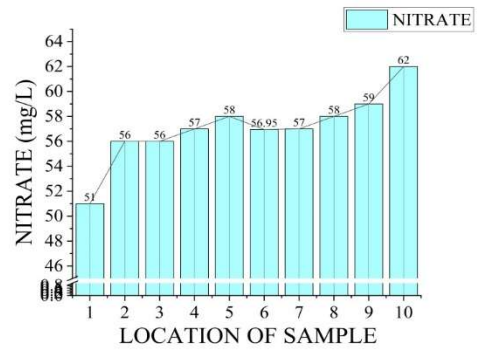


Fig. 6: Graphical Representation of Elevated Nitrate Obtained

The most common pollutants detected in water are TDS, COD, sulfates, and nitrates, which could be seen as indicators of contamination. They contaminate potable water on a very large scale. Its taste and odor get spoiled with high TDS because this gives salty food to water. The elevated COD signifies that the water is exhibiting organic contaminants which lead to the depletion of oxygen from water, as a result, aquatic life would get harmed. Man-made sources of sulfate and nitrate pollution include solid waste pollutants, fertilizers, and industrial discharges. Besides, high concentrations of these harmful components may increase the infant's gastrointestinal spectrum, sometimes to the blue syndrome level.

Figure 7-10 also showed that the primary water quality parameter temporal assessment distribution pattern presented some temporal trends. A tabular summary of the landscape-scale results (from source to mouth) demonstrates high COD, TDS, nitrates, and sulfates levels across the SHC by several orders of magnitude overall indicative of extensive degradation. While levels of toxicity experienced at the endpoints are commensurate in the lower SHC, the temporal differences show multiple toxicity tiers associated with industrial-, agricultural-, and urban-related pollutants. With this temporal pattern of pollution data, the higher and lower class areas or populations are recognized to be likely to be at pollution risk places hence it will help establish an optimum mode for sustainable utilisation of water quality in Sharda Canal.

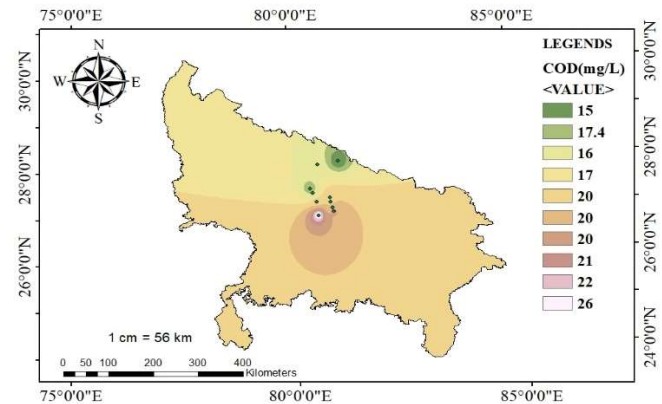


Fig. 7: Temporal Distribution of COD Concentration in Sharda Canal Surface Water

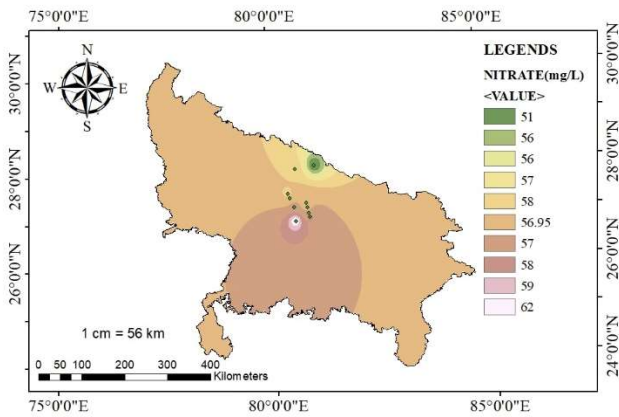


Fig. 8: Temporal Distribution of Nitrate Concentration in Sharda Canal Surface Water

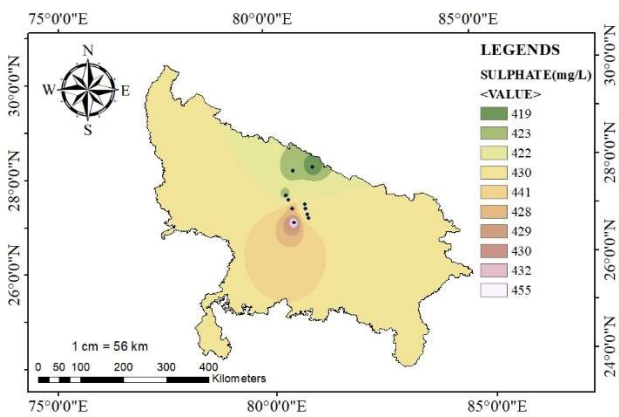


Fig. 9: Temporal Distribution of Sulphate Concentration in Sharda Canal Surface Water

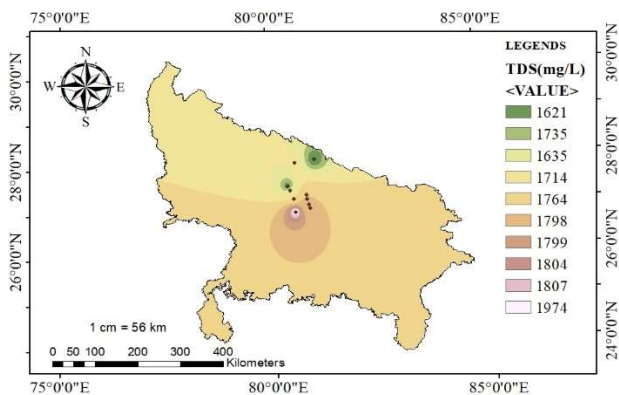


Fig. 10: Temporal Distribution of TDS Concentration in Sharda Canal Surface Water

Also, the authorities in charge should monitor and assess water quality, periodically to pinpoint pollution hotspots and take necessary measures as Sharda Canal by far is an important irrigation source for the appertaining district. Such groundwater sources (one of the most vital groundwater lies beneath some very important natural and man-made habitats) need a collaborative effort by all stakeholders: government agencies, industries as well as local communities to use it sustainably and conserve it to increase efficiency at both ends.

IV. CONCLUSION

The study of WQI shows that water quality in the whole catchment is not suitable. In Sharda Barrage Lakhimpur Kheri the station WQI range was found 110.29 whereas, in Bakshi ka Talab distributary Lucknow, it was 128 with an indication that poor quality of water due to chemical and biological grounds at both selected sites are present. Concurrently with temporal distribution analysis, the presence of various pollutants is visually represented in Fig. 7-10 based on high WQI values corresponding to high TDS, COD, Sulphate, and Nitrate levels higher than desirable ones. The positive solution will contain stricter measures against Intuit and agriculture, dark gray water purification plants, and public information campaigns aimed at shedding as much light on the issue as possible to pressure others (including us) to cut down emissions. Moreover, the development projects should be area-specific, and water quality checks should be made periodically.

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V. REFERENCES

- Acer. Evaluation Study of Sarda Sahayak Pariyojana Programme Evaluation Organisation Planning Commission Government of India New Delhi. 2007.
- Chidiac S, El Najjar P, Ouaini N, et al. A comprehensive review of water quality indices (WQIs): history, models, attempts and perspectives. *Reviews in Environmental Science and Biotechnology* 2023; 22: 349–395.
- Dutta V, Srivastava RK, Yunus M, et al. Restoration Plan of Gomti River with Designated Best Use Classification of Surface Water Quality based on River Expedition, Monitoring and Quality Assessment, <http://www.earthscienceindia.info/80> (2011).
- Hashim KS, Al-Saati NH, Hussein AH, et al. An Investigation into the Level of Heavy Metals Leaching from Canal-Dredged Sediment: A Case Study Metals Leaching from Dredged Sediment. In: *IOP Conference Series: Materials Science and Engineering*. Institute of Physics Publishing, 2018. Epub ahead of print 18 December 2018. DOI: 10.1088/1757-899X/454/1/012022.
- Howladar MF, Al Numanbakhth MdA, Faruque MO. An application of Water Quality Index (WQI) and multivariate statistics to evaluate the water quality around Maddhapara Granite Mining Industrial Area, Dinajpur, Bangladesh. *Environmental Systems Research*; 6. Epub ahead of print January 2018. DOI: 10.1186/s40068-017-0090-9.
- Kumar A, Maurya NS. Groundwater quality assessment using the WQI and GIS mapping: Suitability for drinking and

- irrigation usage in the Sirdala block of Nawada district. *Water Supply* 2023; 23: 506–525.
- Kumar P, Gurukula M, Vishwavidyalaya K, et al. Assessment of Surface Water Quality in Jaunpur District, for Drinking Water and Irrigation Suitability, <https://www.researchgate.net/publication/303920248> (2011).
- Kumar P, Mohan L, Uppaluri RVS. Cyclic desorption based efficacy of polyvinyl alcohol-chitosan variant resins for multi heavy-metal removal. *Int J Biol Macromol* 2023; 242: 124812.
- Kumari R, Sharma RC. Assessment of water quality index and multivariate analysis of high altitude sacred Lake Prashar, Himachal Pradesh, India. *International Journal of Environmental Science and Technology* 2019; 16: 6125–6134.
- Li P, Abbasi T and Abbasi SA: Water Quality Indices. *Environ Earth Sci* 2014; 71: 4625–4628.
- Patel DD, Mehta DJ, Azamathulla HM, et al. Application of the Weighted Arithmetic Water Quality Index in Assessing Groundwater Quality: A Case Study of the South Gujarat Region. *Water (Switzerland)*; 15. Epub ahead of print 1 October 2023. DOI: 10.3390/w15193512.
- Patel PK, Nagireddi S, Uppaluri RVS, et al. Batch adsorption characteristics of Dowex Marathon MSA commercial resin for Au(III) removal from synthetic electroless plating solutions. *Mater Today Proc* 2022; 68: 824–829.
- Patel PK, Pandey LM, Uppaluri RVS. Highly effective removal of multi-heavy metals from simulated industrial effluent through an adsorption process employing carboxymethyl-chitosan composites. *Environ Res*; 240. Epub ahead of print 1 January 2024. DOI: 10.1016/j.envres.2023.117502.
- Patel PK, Pandey LM, Uppaluri RVS. Synthesized carboxymethyl-chitosan variant composites for cyclic adsorption-desorption based removal of Fe, Pb, and Cu. *Chemosphere* 2023; 139780.
- Prasad S, Saluja R, Joshi V, et al. SURFACE WATER QUALITY ASSESSMENT USING MULTIVARIATE STATISTICAL TECHNIQUE AND WATER QUALITY INDEX (WQI) MODELLING IN THE UPPER GANGA RIVER, INDIA. *Poll Res* 2020; 39: 1047–1060.
- Sheikhi S, Shahbazi H, Mosaferi M, et al. Spatio-temporal variation of WQI, scaling and corrosion indices, and principal component analysis in rural areas of Marand, Iran. *Groundw Sustain Dev*; 11. Epub ahead of print 1 October 2020. DOI: 10.1016/j.gsd.2020.100480.
- Tiwari AK, Singh AK, Singh AK, et al. Hydrogeochemical analysis and evaluation of surface water quality of Pratapgarh district, Uttar Pradesh, India. *Appl Water Sci* 2017; 7: 1609–1623.
- Uddin MG, Nash S, Olbert AI. A review of water quality index models and their use for assessing surface water quality. *Ecological Indicators*; 122. Epub ahead of print 1 March 2021. DOI: 10.1016/j.ecolind.2020.107218.
- Vipin Kumar, Mandvi, Shashank Pandey, et al. Assessment of ambient air quality of Lucknow city post monsoon 2023. *World Journal of Advanced Research and Reviews* 2024; 23: 188–201.
- Yadav KK, Singh PK. TEMPORAL VARIATIONS OF GROUNDWATER QUALITY PARAMETERS, <https://www.researchgate.net/publication/359175253>.
- Zakir HM, Sharmin S, Akter A, et al. Assessment of health risk of heavy metals and water quality indices for irrigation and drinking suitability of waters: a case study of Jamalpur Sadar area, Bangladesh. *Environmental Advances*; 2. Epub ahead of print 1 December 2020. DOI: 10.1016/j.envadv.2020.100005.