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Analysis of Physicochemical Characteristics and Water Bodies in the Sarayan River, Lakhimpur, Uttar Pradesh, India

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Abstract

A lesser-known but ecologically vital watercourse in Uttar Pradesh, India's Lakhimpur district, the River Sarayan is lifeblood for the complex biological and socioeconomic environment of the area. Rising in the Himalayan foothills, this river runs through semi-urban areas, agricultural settings, and significant natural ecosystems among other places. Its watershed is a small-scale model of the environmental issues resource consumption, climate change, and fast human activity bring about in northern Indian river ecosystems. In many different respects, this essential water resource promotes local biodiversity, agricultural sustainability, and community livelihoods. The river maintains the ecological balance of the nearby lands, supports regional agricultural activities, provides habitat to a range of aquatic and riparian species, and is a main supply of irrigation water. But the growing needs of urbanization, agricultural intensification, and environmental changes call for a full and nuanced knowledge of its ecological dynamics.

The present work aims to do an integrated and thorough investigation of the River Sarayan using a multifarious approach combining physicochemical investigations with biodiversity assessments. This study intends to give a comprehensive environmental profile of the river by closely assessing water quality measurements, compiling aquatic life, and investigating ecological relationships. By means of a comprehensive ecological assessment, this study intends to increase awareness of the complex interdependencies supporting river ecosystems in the Uttar Pradesh landscape, provide useful insights for local and regional environmental management, and add to the larger scientific debate on river ecosystem preservation.

Keywords: *Physicochemical Characteristics, Water Quality Analysis, Sarayan River Lakhimpur, U.P*

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Introduction

Important ecological corridors that preserve a range of biological systems and provide resources required for the survival of the environment and humans are rivers. Beyond basic water transportation, they are complex, dynamic ecosystems that link terrestrial and aquatic environments, therefore serving a number of important functions. These natural streams are essential conduits for regional biodiversity by maintaining intricate food webs, encouraging nutrient cycling, and providing habitats for a great range of animals at many trophic levels.Nestled in Lakhimpur, Uttar Pradesh, the River Sarayan is a significant body of water with complex ecological interactions that aptly reflect the several purposes of river systems in local environmental dynamics. The river, which rises in the foothills of the Himalayas, flows through a variety of environments, such as semi-urban areas, agricultural plains, and areas with native vegetation. Its watershed, roughly 450 square kilometers, is home to a varied spectrum of human groups and ecological life.

The river has ecological value beyond of its limited geographic boundaries. In addition to supporting agricultural irrigation for nearby farmlands and preserving the hydrological equilibrium of the Lakhimpur region, it is essential for groundwater recharge. The Sarayan River has long been a source of agriculture, drinking water, and traditional livelihoods for the local inhabitants, fostering a close socio-ecological bond that emphasizes the inextricable link between human cultures and river ecosystems.

But the Sarayan suffers several environmental problems, just as many rivers in rapidly expanding regions do. Its ecological integrity has started to be impacted by growing anthropogenic pressures, such as urban garbage disposal, agricultural runoff, and shifting land-use patterns. The ecological dynamics of the river are further complicated by seasonal variations in precipitation and climate variability, making thorough scientific research crucial to comprehending and maintaining the health of the environment. By examining the River Sarayan's physicochemical properties, biodiversity, and ecological interactions, this study seeks to present a comprehensive evaluation of the river. We hope to provide important insights on the river's conservation tactics, environmental management, and sustainable resource use by recording its current condition.

Materials and Methods

Study Area

Along with natural settings, the semi-urban and agricultural districts of Lakhimpur, where the River Sarayan flows, offer a range of sceneries. The study involved several sampling sites from different ecological zones.

Sampling Locations

Three sampling sites along the River Sarayan were selected in order to have a whole view of the water quality.We gathered water samples from the following sites:

Site 1: Sarayan River in Haidarabad Paragana, Gola Gokaranath village, Lakhimpur.

Site 2: The Sarayan River in the village Naurangpur, of Lakhimpur.

Site 3: The Sarayan River at Jamwari, close to Tehar Lakhimpur.

Fields Measurements Portable meters and probes allowed on-site measurements of many physico-chemical parameters, including pH and temperature. These tests were taken immediately following sample collecting to ensure exact readings. Lab Analyzes The gathered water samples were delivered to the lab in an insulated cooler box so as to maintain the appropriate temperature and storage conditions.

Sampling Procedure

Water from the Sarayan River was harvested in 2023. Table shows the typical values of the physicochemical characteristics of river water. Periodically, the quality of the surface water changes and becomes readily contaminated.

Pre-Sampling Preparations:

Samples were gathered in sterile, pre-sterilized polyelene vials to prevent contamination. The bottles were suitably labeled with unique traits including the time, date, and sample site. The manufacturer's directions guided the setup and calibration of the required field tools field meters, ice packs, cooler boxes.

Sample Collection:

At every sampling site, water samples were collected from the middle of the river stream, avoiding areas with standing water or significant turbulence. Using the grab sampling method, the sample vials were submerged 20 to 30 cm below the water's surface and oriented against the current. The bottles were three times cleansed using river water prior to the last sample collecting.

Field Measurements:

On-site specific physico-chemical parameters—including pH and temperature—were monitored using calibrated portable meters and probes. To get the readings, the probes were straightly dipped into the river water following manufacturer directions and accepted practices. The readings were entered either from a field notebook or a dedicated data sheet.

Parameters

pH: Using a digital pH meter to determine.

Alkalinity: The Double Titration Method for Determining Alkalinity.

Water temperature: Using a digital laboratory thermometer to determine the temperature.

Results and Discussion

pH

Many natural and commercial processes depend on pH, a measurement of the basic or acidic character of an aqueous solution. On the pH range, which runs from 0 to 14, seven is said to be neutral. Whereas basic, or alkaline solutions have a pH over 7, acidic solutions have a pH less than 7. pH is important because of its effects on biological and chemical systems. pH affects a wide spectrum of chemical reactions and biological systems since it determines the solubility, reactivity, and stability of many compounds. For aquatic settings, for example, pH is a vital component influencing nutrient availability, pollution toxicity, and aquatic creature viability.

Mainly regulating pH in natural water systems like rivers, lakes, and seas is the balance between carbon dioxide (CO_2), carbonate (CO_3^{2-}), and bicarbonate (HCO_3^-). This balance—known as the carbonate-bicarbonate equilibrium—is affected by the breakdown of carbonate rocks, rates of photosynthesis and respiration, and atmospheric CO_2 levels.

pH variations can have a major effect on aquatic living. Most aquatic life has evolved to fit a specific pH range; hence pH alterations could harm them. For instance, heavy metals could mobilize in acidic conditions, hence raising their bioavailability and toxicity to aquatic life. But ammonia toxicity can increase in alkaline conditions, which could endanger other aquatic species including fish. Many industrial processes, including food manufacture, chemical processing, and water treatment, depend on pH being under control. For instance, pH change is often needed in wastewater treatment to maximize the elimination of pollutants and promote the growth of healthy microorganisms during biological treatment procedures.

Measurement and tracking of pH determine everything from environmental studies to water quality assessments to industrial operations (Parkhurst and Appelo, 2013; Bhattacharya et al., 2021). pH can be calculated in numerous ways including colorimetric indicators, pH meters (Dickson, 1993; Bates, 2012), and electrode-based methods. Traditional colorimetric methods employ indicator dyes that change color at specified pH thresholds to offer visual evaluation capabilities (Clark et al., 2007). Modern pH measurement is mostly based on potentiometric techniques using glass electrodes, which offer higher precision and convenience for field and lab uses (Skoog et al., 2017; Bagotsky, 2019). In a range of environmental settings, temperature-compensated digital pH meters have considerably raised measurement accuracy (Mettler Toledo, 2018; Pankow, 2019). Method choice (APHA, 2017; Kim et al., 2020) is influenced by intended use, sample properties, and accuracy standards. Studies of aquatic ecosystems notably depend on high-precision measurements since even little pH variations can significantly affect biological communities and biogeochemical reactions (Michaelidis et al., 2014; Singh and Agrawal, 2022).

Table 1. Pollution's impact on the Sarayan River's pH at several locations in the Lakhimpur district throughout the year 2023.

SITES	SUMMER SEASON	RAINY SEASON	WINTER SEASON
SITE 1	8.21	7.59	8.61
SITE 2	8.37	7.81	8.56
SITE 3	8.48	7.53	8.53

Alkalinity, a gauge of the water's capacity to neutralize acids, is a fundamental determinant of its quality. It indicates that water capable of serving as a buffer against pH fluctuations contains chemicals, mostly carbonates, bicarbonates, and hydroxides. One often uses calcium carbonate (CaCO3) equivalents to indicate the alkaline character of a given body of water.
Many chemical and biological processes depend on the pH of water being within a particular range, hence alkalinity is crucial. Controlling the carbonate-bicarbonate equilibrium—which maintains the pH balance in natural water bodies depends on alkalinity. Aquatic life depends on this equilibrium since many species have evolved to fit specific pH ranges and can suffer from changes.

Alkalinity comes from the dissolving of rocks and minerals including calcium, magnesium, and potassium carbonates as well as from carbon dioxide dissociation in water. Main sources of alkalinity in natural waterways are silicate minerals, atmospheric carbon dioxide, and carbonate rocks (like limestone and dolomite). Apart from their role as a pH buffer, calcium and magnesium ions constitute a significant share of alkalinity and thereby affect water hardness. While high alkalinity can produce scaling and precipitation issues in industrial operations including boilers and cooling systems, low alkalinity can cause corrosion concerns.
For many applications, including industrial operations, environmental monitoring, and water treatment processes, alkalinity measurement is absolutely vital. Though there are other methods as well, titration techniques are the most generally used method for determining alkalinity. The twofold titration approach using phenolphthalein and mixed bromcresol green-methyl red indicators allows one to find both total alkalinity (including bicarbonates and other basic compounds) and phenolphthalein alkalinity (produced by hydroxides and half the carbonates).

Alkalinity adjustment is often necessary in water treatment operations to maximize chemical coagulation, disinfection, and other treatment processes (Crittenden et al., 2012;

AWWA, 2017). Maintaining optimal alkalinity levels can considerably boost coagulation efficiency, according to Edzwald (2011), by stabilizing pH and encouraging floc development. Moreover, as alkalinity influences chlorine speciation and the production of disinfection byproducts, Binnie and Kimber (2013) demonstrated that effective disinfection depends on proper alkalinity control.

Alkalinity is used in environmental monitoring as a measure of water bodies' buffering capacity and can expose information about the effects of acidic pollutants or changes to the carbonate system brought on by factors like ocean

acidification (Schindler, 1988; Stumm and Morgan, 2012). Long-term studies by Stoddard et al. (1999) indicate that monitoring alkalinity trends can help to spot early signs of the recovery of freshwater ecosystems from acidification. Furthermore, Doney et al. (2009) showed that monitoring ocean acidification and its effects on marine life and ecosystems depends much on differences in alkalinity and related carbonate parameters.

Table 2. Impact of pollutants on the river Sarayan's overall alkalinity (mg/l) at several locations in the Lakhimpur district throughout the course of the year 2023.

SITES	SUMMER SEASON	RAINY SEASON	WINTER SEASON
SITE 1	182	165	136
SITE 2	214	189	165
SITE 3	176	141	123

Temperature is a fundamental factor influencing many chemical, physical, and biological processes in aquatic environments, hence it is a crucial parameter for the evaluation and control of water quality. Temperature swings in water bodies can be brought on by both natural factors such seasonal variations and manmade activity including urban runoff and industrial discharges. Water quality is particularly important since temperature influences several important activities.

Temperature determines how soluble gases like carbon dioxide and oxygen are in water. In pools of either stagnant or slowly flowing water especially, less dissolved oxygen in warmer water can have a deleterious effect on aquatic life.

Temperature directly affects the metabolic rates of aquatic life including fish, algae, and bacteria. Generally speaking, hotter temperatures boost metabolic rates, which could throw off the ecological equilibrium by generating more waste and raising the oxygen demand.

Chemical reactions: Several chemical reactions and processes depend on the water temperature. Variations in temperature, for instance, can influence chemical degradation, nutrient cycling, and pollution conversion speed.

Temperature fluctuations in deeper bodies of water can lead to thermal stratification—that is, separate layers of water with different temperatures forming. This stratification may affect the distribution of nutrients, dissolved oxygen, and other components, therefore influencing the dynamics of an ecosystem and the general water quality. Many uses including those regarding water quality depend on temperature monitoring.

Temperature influences how efficiently biological treatment processes operate since microorganisms breaking down organic matter have preferred temperature ranges. Temperature affects both the solubility and pollution removal as well as the efficacy of disinfection processes like chlorination.

Monitoring temperature fluctuations in bodies of water helps one to learn about the effects of human activity, climate change, and other environmental factors on aquatic ecosystems. Many industrial operations using water, including chemical manufacturing or cooling systems, depend on temperature management and monitoring to ensure maximum performance and compliance with environmental criteria. Commonly used thermometers or temperature probes for field or water sample detection of temperature are Continuous monitoring tools also let one follow temperature variations over time.

Table 3. Pollution's impact on the river Sarayan's water temperature (^{0}C) at several locations in the Lakhimpur district throughout the year 2023.

SITES	SUMMER SEASON	RAINY SEASON	WINTER SEASON
SITE 1	31.2	26.2	8.2
SITE 2	31.6	27.2	9.1
SITE 3	30.4	27.4	9.2

Table 4: Water bodies of River Sarayan, Lakhimpur, Uttar Pradesh, India

Labeo rohita (Rohu) *Catla catla* (Catla) *Cirrhinus mrigala* (Mrigal) *Labeo calbasu* (Kalbasu) *Labeo bata* (Bata) *Puntius sarana* (Olive Barb) *Puntius ticto* (Ticto Barb) *Salmostoma bacaila* (Large Razorbelly Minnow) *Amblypharyngodon mola* (Mola Carplet) *Rasbora daniconius* (Slender Rasbora) *Channa punctata* (Spotted Snakehead) *Channa striata* (Striped Snakehead) *Channa marulius* (Great Snakehead) *Mystus seenghala* (Giant River Catfish)	*Parambassis ranga* (Indian Glassy Fish) *Glossogobius giuris* (Tank Goby) *Anabas testudineus* (Climbing Perch) *Hoplobatrachus tigerinus* (Indian Bullfrog) *Euphlyctis cyanophlyctis* (Indian Skipper Frog) *Sphaerotheca breviceps* (Indian Burrowing Frog) *Duttaphrynus melanostictus* (Asian Common Toad) *Polypedates maculatus* (Indian Tree Frog) *Pangshura tecta* (Indian Roofed Turtle) *Pangshura tentoria* (Indian Tent Turtle) *Kachuga kachuga* (Red-crowned Roofed Turtle) *Lissemys punctata* (Indian Flapshell Turtle) *Nilssonia gangetica* (Indian Softshell Turtle) *Xenochrophis piscator* (Checkered Keelback) *Amphiesma stolatum* (Buff-striped Keelback)

Mystus vittatus (Striped Dwarf Catfish) *Mystus cavasius* (Gangetic Mystus) *Rita rita* (Rita) *Wallago attu* (Wallago) *Ompok bimaculatus* (Butter Catfish) *Heteropneustes fossilis* (Stinging Catfish) *Clarias batrachus* (Walking Catfish) *Ailia coila* (Gangetic Ailia) *Mastacembelus armatus* (Zig-zag Eel) *Macrognathus pancalus* (Barred Spiny Eel) *Chanda nama* (Elongate Glass-perchlet)	*Naja naja* (Indian Cobra) - In riparian zones *Bungarus caeruleus* (Common Krait) - In riparian zones *Baetis* species *Caenis* species *Ephemera* species *Crocothemis servilia* (Scarlet Skimmer) *Orthetrum sabina* (Green Marsh Hawk) *Pantala flavescens* (Wandering Glider) *Ischnura* species (Damselflies) *Copera marginipes* (Yellow Bush Dart)

Conclusion

Particularly with regard to its pH, alkalinity, and temperature, the careful analysis of the physico-chemical properties of the River Sarayan at Lakhimpur, Uttar Pradesh, has clarified the dynamics of this vital water source and its current water quality condition. These qualities have a major influence on many chemical, biological, and ecological processes inside the river environment. The investigation revealed notable variations in pH levels among the numerous sampling locations around the River Sarayan. While some sites showed pH values outside of the permitted range, others showed changes that pointed toward either an acidic or alkaline surroundings. Among the sources of these pH fluctuations include industrial effluencies, agricultural runoff, and natural geological processes. Maintaining an optimal pH range determines not only the general health of the river environment but also the presence and wellbeing of aquatic species. The alkalinity readings exposed the buffering capacity of the river water, which is necessary to regulate pH fluctuations and reduce the consequences of acidic pollutants. The study found that the presence of carbonate and bicarbonate ions—probably derived from surrounding rocks and minerals dissolving—caused some areas to have greater degrees of alkalinity than others. In water distribution systems, low alkalinity can increase corrosion risk; high alkalinity can lead to hard water and scaling issues.

One of the main factors this study considered—temperature—showered notable differences between seasons and sampling sites. These temperature fluctuations significantly affect the dissolution of essential gases, such as carbon dioxide and oxygen; they also affect the metabolic activities of aquatic life (Singh and Mathur, 2005; Pörtner and Farrell, 2008). Kaushal et al. (2010) claim that even minor temperature variations can have a major impact on the physiological processes of aquatic life, therefore influencing their capacity for reproduction, development, and generally survival. Usually, temperature rises result in reduced oxygen concentrations, which can disturb the natural balance of the river and provide bad conditions for aquatic life (Woodward et al., 2010; Verma and Choudhary, 2018). Research by Dubey et al. (2020) in comparable riverine environments across the Indo-Gangetic plains shows that seasonal temperature fluctuations of 5–8°C can greatly change macroinvertebrate populations and lower ichthyofaunal diversity. Tripathi et al. (2014) also demonstrated how human-caused components, such as the discharge of warm wastewater and the destruction of vegetation along riversides, may accentuate natural temperature variations and raise biological stressors in freshwater habitats. The findings of this study underline the need of careful management strategies and monitoring for the water quality of the River Sarayan. Locating prospective pollution sources, assessing the consequences of human activities, and implementing appropriate mitigating measures depend on regular measurements of temperature, pH, and alkalinity as well as other physico-chemical parameters. Solving the found problems calls for a multifarious strategy to preserve the ecological integrity and long-term survival of the River Sarayan. This might comprise. Strict regulations and policies enforced help to control industrial and agricultural pollutants and assure adherence to water quality criteria. Encouragement of sustainable farming practices and efficient water management policies will help to lessen the detrimental consequences of agricultural runoff on river water quality. Enhancing public awareness campaigns and community involvement projects to inculcate responsibility and support ecologically friendly behavior among relevant players. Establishing and implementing all-encompassing river management and conservation strategies by means of cooperation projects among local government, businesses, and communities.

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