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Geological Control On Avian Biodiversity In Urban Lakes: A Case Study On Dalpat Sagar Lake Of Bastar Region

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Abstract
Urban lakes and ponds function as ecological hubs that support both migratory and resident avifauna. Although the biological and climatic factors shaping bird distribution are well documented, geological determinants of avian biodiversity remain comparatively underexplored. This study examines how lithology and hydro geochemistry influence avian biodiversity in Dalpat Sagar; a plateau lake located within the Bastar Craton of central India. The crystalline basement geology, lateritic and alluvial soil cover, and seasonal hydroperiod collectively regulate nutrient cycling, littoral zone development, and trophic productivity, thereby affecting habitat suitability for birds. A multidisciplinary approach—comprising geological surveys, hydro-chemical analysis and avian diversity surveys and review—is proposed. The results indicate that geology indirectly shapes lake-based food webs and the stability of migratory habitats. A geology-informed conservation framework is recommended to support sustainable lake management for sound preservation of such vital biodiversity hotspots like: Dalpat Sagar.

Keywords: *Lithology, hydro-geochemistry, avian biodiversity, nutrient cycling.*

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I. Introduction

Wetlands and freshwater lakes provide as essential habitats for both resident and migratory avifauna. Habitat suitability within freshwater ecosystems is largely influenced by hydrological and ecological variables, including water depth, the duration of water retention (hydroperiod), availability of food resources, structure of aquatic and shoreline vegetation, and overall water quality. Together, these factors influence species diversity, feeding patterns, and seasonal movement of birds. However, these ecological characteristics do not develop independently. They are strongly influenced by the geological setting of the lake. The underlying rock types, soil properties, and basin structure play a fundamental role in shaping hydrological processes and environmental conditions within the ecosystem.

Geology plays a fundamental role in shaping the physical and chemical nature of a lake ecosystem. The type of rocks present in an area determines how the lake basin is formed and how stable it remains over time. It also influences the permeability of the soil, which controls how much water infiltrates into the ground and how much remains stored on the surface. The composition of sediments within the lake is largely derived from the surrounding rocks through weathering and percolation processes. As rocks break down physically and chemically, they release minerals and nutrients into the water system. These nutrients can support biological productivity.

Furthermore, the geomorphological features of the landscape such as slope gradient, basin shape, and shoreline configuration which determine the development of littoral zones. These shallow areas are especially important because they support aquatic plants, invertebrates, and fish, creating diverse microhabitats. Such habitat variation, often referred to as habitat heterogeneity, enhances ecological complexity within the lake. Through these interconnected processes, geology indirectly regulates food availability and ecosystem productivity.

Dalpat Sagar is located in Jagdalpur city of Bastar region of Chhattisgarh and forms part of a plateau landscape underlain by Archean crystalline rocks of the Bastar Craton. The area is mainly composed of granitic gneisses with a widespread lateritic soil cover and alluvial presence, creating a distinct geological setting. This

geological background influences the hydrological functioning of the lake, including water movement, storage capacity, and the release and cycling of nutrients derived from rock weathering. The present study examines the proposition that these geological characteristics play a significant role in shaping patterns of avian biodiversity in Dalpat Sagar by determining the lake's physical structure and chemical environment.

Fig.1. Field image of Dalpat Sagar Lake, Jagdalpur city, Bastar, Chhattisgarh.

II. Lithology Of The Study Area

The stratigraphy succession of the Indravati basin proposed by Crookshank (1963) and Sharma (1975) on the basis of field relationship of various litho-units is as follows:

Table.1. Stratigraphic succession of Indravati Basin based on Crookshank (1963) and Sharma (1975).

STRATIGRAPHICAL SUCCESSION OF INDRAVATI BASIN		
Formation	**Lithology**	**Thickness (in m)**
Jagdalpur Formation	Purple shale with purple and grey stromatolitic dolomite.	150-200m
Kanger Limestone	Purple limestone and shale, grey limestone.	150m
Cherakur Formation	Purple shale with arkosic sandstone, chert, pebble, conglomerate, grit.	50-100m
Tirathgarh Formation	Upper member- Quartz arenite (Chitrakot Sandstone member) Lower member- Subarkose and conglomerate (Mendri member)	50-100m
Granite and Supracrustals		

The field observations have made it obvious for us that the upper most layer of Indravati basin composing of shale and dolomite are accompanied by lateritic soil cover and hint of alluvial soil. The presence of laterite as a capping layer on the upper most formation is a common appearance in plateau regions like Bastar craton. Laterite has high porosity and presence of macropores, all of which promotes inflow of nutrients in the lake body by the process of surface runoff, percolation and lateral movement.

In collaboration to this the availability of alluvial soil promotes the infiltration and lateral subsurface flow of nutrients from surface run off and agricultural run offs into the Dalpat Sagar lake. As the alluvial soil has loose and granular structure, moderate to high permeability and high porosity and transportation property, all of which leads to above mentioned role playing in nutrient enrichment of the lake leading to endangerment of aquatic invertebrates and fishes.

III. Nutrient Enrichment Of Dalpat Sagar Lake

Source of nutrients in the Dalpat Sagar lake

The contamination in the lake is of non-point nature, the observational outcomes have suggested that the nutrient inflow of the lake is from agricultural transmission, municipal dumping, industrial run off and also from domestic dumping.

Eutrophication of Dalpat Sagar Lake

The leading reasons for eutrophication in nutrient inflow in an aquatic system and that is very clearly observed in the study area, the eutrophic state of the lake has been delineated with help of Secchi disc method as well as chemical analysis of lake water.

Station No.	Latitude & Longitude	Lake Depth (m)	D_1(m)	D_2(m)	Secchi Depth
S_1	19.096476351167095, 82.01227011107636	7.30	1.40	1.60	1.50
S_2	19.098666234890135, 82.01218428038844	6.85	1.60	1.80	1.70
S_3	19.093840341585686, 82.01218428038844	5.00	1.00	1.20	1.10
S_4	19.098422915907566, 82.01711954494347	4.57	1.50	1.70	1.60
S_5	19.094691980041308, 82.01802076716653	3.96	1.70	1.90	1.80
S_6	19.098706788019108, 82.00827898408839	3.20	1.30	1.50	1.40
S_7	19.09363756987895, 82.00784983064884	5.50	1.20	1.40	1.00
S_8	19.0946514259285, 82.00488867191582	3.65	0.90	1.10	1.00
S_9	19.097611850048338, 82.0036441269411	2.90	0.80	1.00	0.90
S_{10}	19.096395243806008, 82.0102530899104	6.10	1.80	2.00	1.90

Table.2. Secchi Data collection from the Dalpat Sagar lake in Pre-Monsoon Season with concerned latitude and longitude. (SD: 1.5-1.9m- Mesotrophic tendency, SD: 0.8-1.2m- Eutrophic tendency)

B.1. Interpretation of the Secchi Data collection

1. S_1, S_2 & S_{10}: Deeper central station, slightly better transparency indicates Mesotrophic tendency.

2. S_3, S_7, S_8, S_9: Shallower marginal stations, lower Secchi depth indicates Eutrophic tendency.

B. Hydro-chemistry of Dalpat Sagar Lake

Table.3. Tabular representation of hydro-chemistry of Dalpat Sagar Lake. Taken from the chemical analysis in Pre-Monsoon Season from the District Water Testing Laboratory PHE Division Jagdalpur, District- Bastar (C.G).

Sample No.	Turbidity (NTU)	TDS at 180^0C (mg/L)	Total Hardness as $CaCO_3$ (mg/L)	Total Coliform Bacteria (CFU/100ml)	Spec. Conductivity (µS/cm)
S_1	6.2	122	138.02	Present	232
S_2	7.8	152	123.87	Present	235
S_3	29.1	292	233.53	Present	540
S_4	8.8	266	121.34	Present	398
S_5	8.5	134	139.02	Present	344
S_6	9.9	122	138.43	Present	490
S_7	29.9	299	245.01	Present	550
S_8	32.2	304	239.88	Present	543
S_9	30.1	389	221.90	Present	539
S_{10}	6.6	120	121.54	Present	222

C.1. Interpretation of the hydro-chemical analysis of study area

1. Elevated Turbidity suggests possible phytoplankton bloom and presence of suspended matter.
2. High coliform count is representative of organic inflow which is generally associated with nutrient enrichment.
3. Higher conductivity indicates presence of dissolved nutrient salts due to anthropogenic run-off.

Based on the characteristics of these interpretations it will be appropriate to comment on that the lake eco-system is consistent with nutrient enriched or eutrophic ecosystem.

IV. Established Relationship Between Geology And Avian Bio-Diversity

Lithology

Lithology refers to the physical characteristics of a rock unit, including its mineral composition, grain size, texture, and colour.

Formation of Soils

Soil formation (pedogenesis) is the process by which soils are produced from the weathering of rocks and minerals and the subsequent modification of these materials by physical, chemical, and biological processes operating at or near the Earth's surface.

Dynamics of Runoff

Runoff is that part of precipitation that appears in surface streams, including surface runoff, interflow, and baseflow, and represents the integrated hydrologic response of a drainage basin.

Composition of Sediments

Sediment composition refers to the relative proportions of mineral grains, rock fragments, and biogenic materials that constitute a sediment, reflecting the nature of the source rocks, weathering processes, transport history, and depositional environment.

Cycling of Nutrients

Nutrient cycling refers to the movement and exchange of organic and inorganic matter back into the production of living matter through biogeochemical processes operating within and between the lithosphere, hydrosphere, atmosphere, and biosphere.

Primary Productivity

Primary productivity is the rate at which autotrophic organisms, principally photosynthetic algae and aquatic plants, convert inorganic carbon and nutrients into organic matter through photosynthesis; this process forms the energetic and material base of aquatic food webs and regulates the abundance and diversity of higher trophic levels, including invertebrates and fish.

Diversity of Invertebrates and Fish

Diversity of invertebrates and fish refers to the variety and relative abundance of species, functional groups, and trophic guilds of aquatic macroinvertebrates and fish within a water body, reflecting ecological integrity, habitat heterogeneity, water quality conditions, and nutrient status.

Diversity of Avian

Avian diversity refers to the variety, richness, and relative abundance of bird species within a defined habitat or ecosystem, reflecting habitat structure, resource availability, environmental quality, and ecological stability.

V. Comment On Avian Bio-Diversity Of Dalpat Sagar Lake And Adjoining Areas

As part of the broader Bastar Plateau avifaunal region, which supports 304 species belonging to 194 genera and 63 families, Dalpat Sagar functions as an important wetland node contributing substantially to regional bird diversity.

Species Richness and Habitat Heterogeneity

Wetland systems of the Bastar Plateau, including Dalpat Sagar, Rajnagar Dam, Bakavand Dam, and Ulnar Dam, have been identified as prominent avian hotspots. Dalpat Sagar alone sustains more than 50 species of wetland-dependent birds, many of which utilize the lake for roosting and breeding.

The ecological configuration of the lake enhances its suitability for a diverse avifauna. Submerged and emergent macrophytes furnish feeding and nesting habitats. The presence of littoral vegetation and two central islands, bearing tree species including Ficus bengalensis, F. religiosa, Mangifera indica, and Lannea grandis, creates vertical habitat complexity that simultaneously supports piscivores, waders, perching birds, and raptors. Such habitat heterogeneity fosters niche differentiation and elevates overall avian richness.

Migratory Importance

Across the Bastar Plateau, 81 species are migratory, predominantly winter visitors, highlighting the region's significance of wetlands as seasonal refugia. Dalpat Sagar lies along potential migratory routes, as demonstrated by the documented roosting of the Near Threatened Spot-billed Pelican (Pelecanus philippensis) during its non-breeding dispersal period. This record suggests that Jagdalpur and the Bastar region may lie within an expanding or shifting migratory corridor for certain large waterbirds.

The repeated pelican observations across several months indicate that Dalpat Sagar provides suitable feeding and roosting opportunities for large-bodied piscivorous birds. Consequently, the lake can be characterized ecologically as a functional stopover site and seasonal habitat, rather than merely a local waterbody.

Fig.2.Darter spotting at Dalpat Sagar Lake.

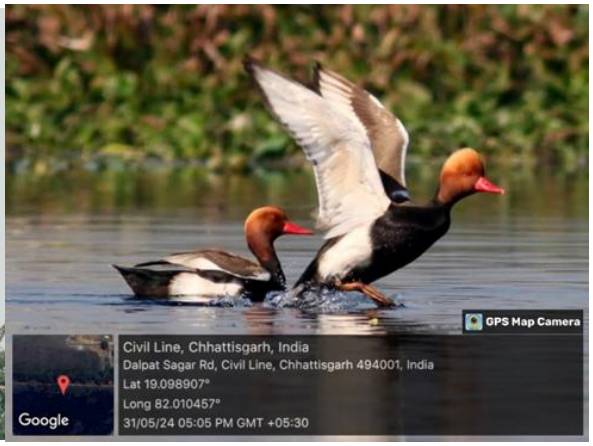

Fig.3. Red-crested pochard winter visitor.

Fig.4. Nearly threatened Pelican at Dalpat Sagar Lake.
(Source: personal collection from Dr. S.K. Dutta)

VI. Conclusion

Dalpat Sagar emerges as an important urban wetland within the Bastar Plateau, sustaining diverse bird life including resident, migratory, and threatened species. The broader region hosts over 300 recorded bird species, with wetlands like Dalpat Sagar recognized as key biodiversity zones. The lake supports more than 50 wetland-associated birds and functions as a wintering site for migratory species, including the Near Threatened Pelecanus philippensis

Hydro-chemical analysis of lake water indicates elevated conductivity and dissolved solids point toward anthropogenic nutrient influx, while increased coliform counts reflect organic loading from urban and peri-urban sources. The physico-chemical profile indicates a nutrient-enriched system with a strong eutrophic tendency.

Dalpat Sagar exhibits a transitional system where moderate eutrophication enhances avian abundance due to increased trophic support, but if continued nutrient loading may reduce species richness through habitat homogenization. This dual role of eutrophication, both as a productivity enhancer and biodiversity threat offers a nuanced ecological perspective rather than a simplistic degradation narrative.

VII. Conservation & Mitigation Measures

1. Nutrient inputs into the lake should be minimized through proper treatment of sewage using decentralized wastewater systems and by ensuring responsible disposal of domestic waste. Developing vegetated buffer zones and sedimentation areas along the shoreline can further help limit external nutrient entry and maintain the ecological health of the lake.

2. Establish a long-term ecological monitoring program that includes annual evaluation of key trophic indicators. Including seasonal bird surveys and periodic fish diversity assessments to understand food web dynamics and support avian conservation planning.
3. Anthropogenic disturbances is to be carefully managed by restricting boating during peak migratory periods, strengthening anti-poaching measures in coordination with the Forest and Municipal Department, and minimizing noise levels during critical breeding seasons to safeguard avian habitats.

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