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Diversity of Macroinvertebrates in the River Kankai, Eastern Nepal

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ABSTRACT
The River Kankai in eastern Nepal, shaped by various human activities, presents a significant opportunity to examine freshwater macroinvertebrate diversity, which indicates ecosystem health and environmental conditions. This study aims to investigate the macroinvertebrate diversity of the River Kankai. Macroinvertebrate species were collected using plankton nets, gloves, and forceps from January 2023 to December 2024 across six sampling stations, identifying 20 species. The assemblage was dominated by Arthropoda (13 species), followed by Mollusca (5 species) and Annelida (2 species). Diversity indices, such as Shannon-Wiener, Simpson, and Margalef, revealed spatial variations: while species evenness increased downstream, species richness declined, likely due to anthropogenic pressures such as irrigation, hydropower, and cultural practices. One-way analysis of variance (ANOVA) indicated no significant differences ($p < 0.05$) in diversity indices among the sampling stations. Principal Component Analysis (PCA) identified environmental gradients and site-specific factors influencing biodiversity. The high inter-station correlation ($r > 0.99$) suggested consistent environmental influences, although unique diversity patterns were observed upstream. Arthropods, the dominant group, displayed adaptability to a range of ecological conditions, while molluscs and annelids indicated the presence of less disturbed habitats. The findings underscore the importance of targeted conservation efforts, including pollution control, habitat restoration, and community engagement, to protect biodiversity and inform policy development. This pioneering research establishes baseline data for the long-term monitoring and management of the River Kankai's ecosystem, serving as a reference point for riverine biodiversity studies in Nepal. Future research should focus on integrating molecular and functional diversity to enhance understanding of ecosystem dynamics and resilience.

Key words: Macroinvertebrates, Biodiversity, Correlation, PCA, Freshwater ecosystem

INTRODUCTION

Freshwater macroinvertebrates are effective indicators of the overall health of ecosystems and have long been used for reliable bio-monitoring (Lucadamo et al. 2008). These aquatic organisms assist in monitoring environmental quality (Loeb and Spacie 1994), enabling the evaluation of the effects of various anthropogenic stressors across all levels of biological organisation, from molecular to ecosystem levels (Carter et al. 2017). The River Kankai flows through hilly and flat regions with varying ecological conditions and is ecologically significant in eastern Nepal. However, the study of macroinvertebrates in this area remains largely unexplored. The River's banks are home to hydropower stations, irrigation projects, picnic spots, and markets, making it essential to study macroinvertebrate diversity in relation to various forms of pollution. Additionally, cultural activities such as annual fairs, Chhath Puja, and death rituals impact the status of macroinvertebrates and water quality. Researchers have conducted various studies on aquatic macroinvertebrate fauna, recognising the importance of macroinvertebrates. Some research has emerged from water bodies in Nepal, focusing primarily on annelids and aquatic arthropods. Malla et al. (1978) studied aquatic insects from various water bodies in the Kathmandu Valley and reported 59 different species. Yadav et al. (1983) explored the biological parameters of Taudah Lake, Kathmandu, documenting 36 species of macroinvertebrates, including major groups such as Oligochaeta, Ephemeroptera, Chironomidae, and Mollusca. Mahato and Yadav (1984) reported 31 species of macroinvertebrates from two ponds in the Mahottary district of Nepal. Regarding molluscs, Sharma (1996) identified 18 species of gastropods and 10 species of bivalves from the Koshi river basin area spanning Nepal and India (Northern Bihar). Subba and Ghosh (2008) presented a list of molluscs collected from nine districts, reporting 25 species.

Bhandari et al. (2018) researched benthic macroinvertebrates in five tributaries of the Budhiganga River in western Nepal. This recent work aims to enhance our understanding of the diversity of macroinvertebrate fauna in the River Kankai, evaluating its ecological health and biodiversity and addressing an existing gap in research on this subject in the region.

MATERIALS AND METHODS

Study area

The study area (Fig.1) includes the River Kankai, which primarily originates from the Sandakpur Mountain and flows from north to south through the hills of Ilam district and the plains of Jhapa district. Ultimately, it enters the state of Bihar in India, where it merges with the River Ganga, encompassing a drainage area of approximately 1,140 km² (Rai 2004). The landscape within the river valley is characterised by significant variation. The Kankai basin serves as a natural habitat for a diverse array of faunal and floral species and is revered as a holy river by Hindu devotees in Nepal. The Kankai Irrigation Project, launched by the Nepalese government, provides irrigation for the southern regions of Jhapa, including Shivaganj, Pachgachi, and Mahabhara. Various tourist destinations along the River Kankai include Maipokhari, Chepti, Dhanuskoti, and Domukha. During the monsoon season, the River floods the fertile plains of Jhapa, inundating thousands of hectares of land. Local fishermen can often be seen casting their nets in the River, while children frequently bathe in its waters during the hot season. Each January, the Kankai and Shivasatakshi municipalities collaboratively host Mai Mela, an

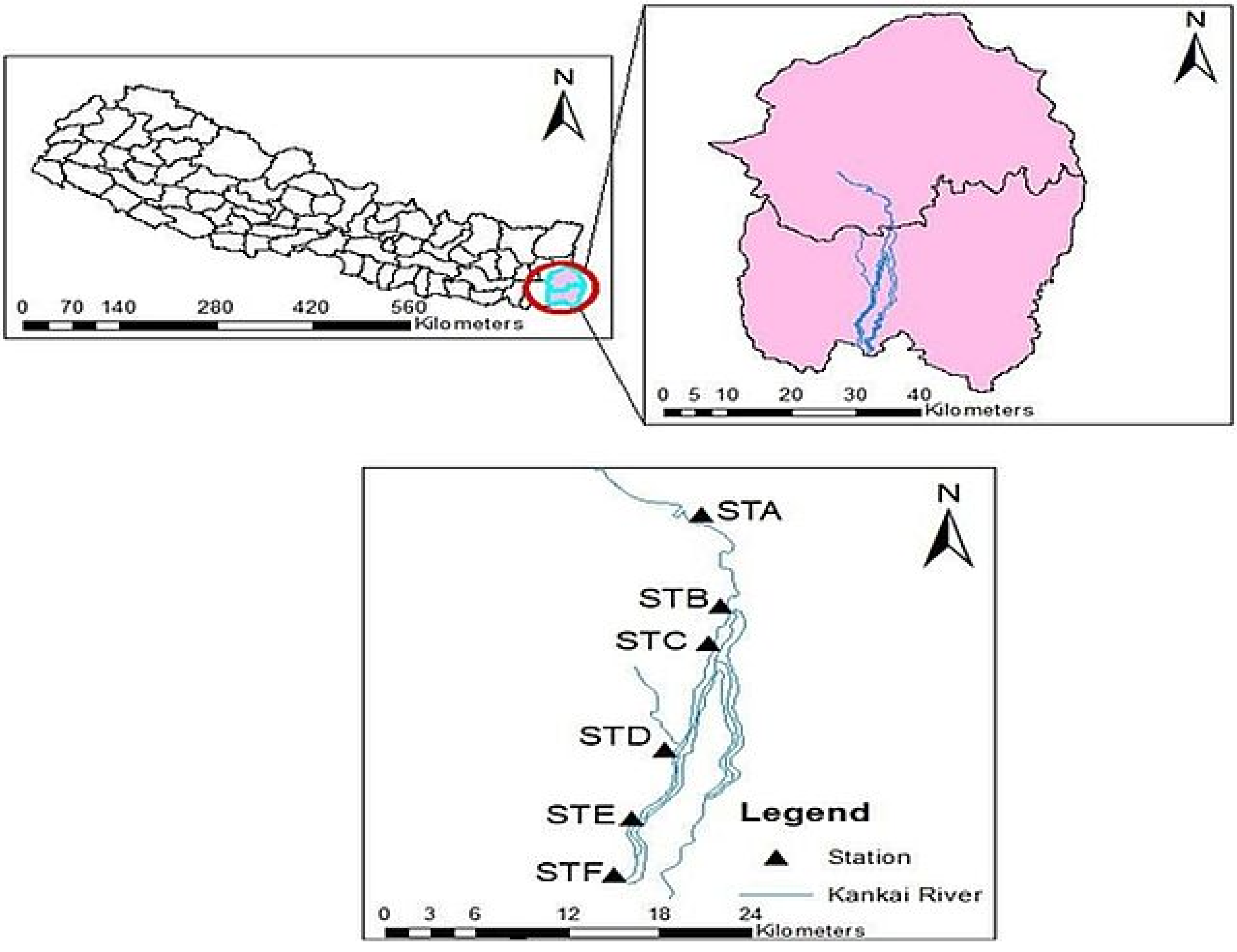

Figure 1. Study area and sampling stations

annual fair that attracts thousands of participants from eastern Nepal and India for religious observances and festivities. Additionally, Kankai Aryaghat situated along both banks of the River, serves as a location where residents perform death rituals.

Data collection, identification and analysis

Aquatic dip nets with a mesh size of 500 µm and plankton nets, gloves, and forceps were utilised to collect macro-invertebrates. Species identification was facilitated through various references, including Allan (1995), Baker (1928), Datta Munshi and Datta Munshi (1995), and Pennak (1953). The macroinvertebrate specimens were gathered from January 2023 to December 2024. Statistical analyses were conducted using Excel, PAST, and RStudio software. Diversity indices, one-way analysis of variance (ANOVA), and Pearson correlation coefficients of the diversity indices (Anderson et al. 2006) were calculated across the different sampling stations.

RESULTS

The study identified a total of 20 macroinvertebrate species, 13 species belonging to the phylum Arthropoda, followed by five species from Mollusca and two species from Annelida (Fig. 2).

The aquatic macroinvertebrate species were documented during the study, encompassing three major invertebrate phyla: Arthropoda (Crustacea and Insecta), Mollusca (Gastropoda and Bivalvia), and Annelida (Hirudinea and Oligochaeta). Crustaceans represented the most diverse group, with nine species under the order Decapoda, including prawns and freshwater crabs. Notable species such as *Macrobrachium lamarrei* and *Macrobrachium altifrons* were categorized as Least Concern (LC) on the IUCN Red List, while several crab species, including *Barytelphusa lugubris* and *Himalayapotamon atkinsonianum*, remained Not Evaluated (NE). Insect diversity was comparatively lower, with four species identified from orders Hemiptera, Psocoptera, and Odonata. Among these, *Anisogomphus bivittatus* was listed as LC, while the rest were NE. Molluscs were represented by six species across Gastropoda and Bivalvia, all of which were listed as LC, suggesting a relatively secure conservation status. Two annelid species, *Hirudinaria granulosa* and *Pheretima posthuma*, were both categorized as NE. Overall, nine species (45%) were assessed as LC, while the remaining eleven (55%) were NE, indicating a significant gap in conservation data (Table 1).

The ecological diversity indices of macroinvertebrates varied slightly across six sampling stations (Table 2). Shannon's diversity index (H) ranged from 2.778 at Station A to 2.885 at Station E, indicating relatively high and consistent species diversity. Simpson's index showed similar trends, with values above 0.92 at all stations, suggesting low dominance and high evenness. Dominance values were lowest at Station D (0.05828), indicating minimal species dominance. Margalef's richness index ranged from 3.265 to 3.766, with the highest richness at Station A. Overall, the diversity indices suggest a stable and diverse macroinvertebrate community across the sampled stations.

The Pearson correlation matrix shows a very strong positive correlation between diversity indices across all six sampling stations, with coefficients ranging from 0.9909 to 1 (Table 3). This indicates a high level of similarity in diversity patterns across the stations. The highest correlation (r = 1) was observed between Stations D and F, and the lowest (r = 0.9909) between Stations A and F. Such strong correlations suggest that ecological conditions influencing diversity are consistent throughout the

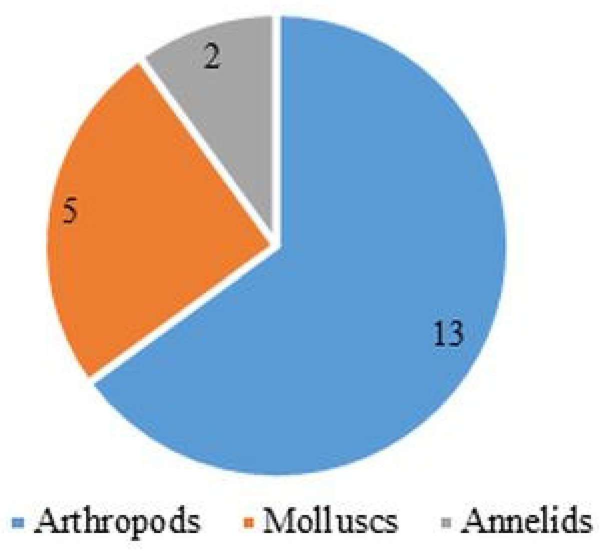

Figure 2. Macroinvertebrate distribution

Table 1. Coding of the macroinvertebrates by phylum, class, order, species and IUCN status

Phylum/Class	Order	Code	Species	IUCN status
Arthropoda				
Crustacean	Decapoda	C1	*Macrobrachium lamarrei* (Edwards 1837)	LC
Crustacea	Decapoda	C2	*Macrobrachium altifrons* (Henderson 1893)	LC
Crustacea	Decapoda	C3	*Barytelphusa lugubris* (Wood-Mason 1871)	NE
Crustacea	Decapoda	C4	*Himalayapotamon atkinsonianum* (Wood-mason 1871)	NE
Crustacea	Decapoda	C5	*Lobothelphusa woodmasoni* (Rathbun 1905)	NE
Crustacea	Decapoda	C6	*Acanthopotamon martensi* (Wood-mason 1875)	NE
Crustacea	Decapoda	C7	*Liotelphus gogei* (Alcock 1909)	NE
Crustacea	Decapoda	C8	*Acanthopotaman fungosum* (Alcock 1909)	NE
Crustacea	Decapoda	C9	*Paratelphusa spinigera* (Wood-Mason 1871)	NE
Insecta	Hemiptera	C10	*Nepa cinerea* (Linnaeus 1758)	NE
Insecta	Hemiptera	C11	*Ranatra linearis* (Linnaeus 1758)	NE
Inecta	Psocoptera	C12	*Trogium pulsatorium* (Linnaeus 1758)	NE
Insecta	Odonata	C13	*Anisogomphus bivittatus* (Selys 1854)	LC
Mollusca				
Gastropoda	Architaenioglosaa	C14	*Belammya bengalensis* (Lamarck 1822)	LC
Gastropoda	Architaenioglosaa	C15	*Lymnaea acuminata* (Lamarck 1822)	LC
Gastropoda	Neotaenioglossa	C16	*Thiara tuberculata* (Muller 1774)	LC
Bivalvia	Unioni	C17	*Parreysia caerulea* (Lea 1831)	LC
Bivalvia	Unionida	C18	*Lamellidens marginalis* (Lamarck 1819)	LC
Annelida				
Hirudinea	Gnathobdellida	C19	*Hirudinaria granulosa* (Lamarck 1818)	NE
Oligochaeta	Opisthopora	C20	*Pheretima posthuma* (Vailliant 1868)	NE

Table 2. Station-wise diversity indices of Macroinvertebrates

Diversity indices	Station A	Station B	Station C	Station D	Station E	Station F
Dominance	0.07083	0.06524	0.06085	0.05828	0.05883	0.05957
Simpson_D	0.9292	0.9348	0.9391	0.9417	0.9412	0.9404
Shannon_H	2.778	2.796	2.867	2.882	2.885	2.88
Margalef	3.766	3.393	3.474	3.274	3.297	3.265

Table 3. Pearson correlation coefficients of diversity indices

	Station A	Station B	Station C	Station D	Station E	Station F
Station A		0.99651	0.99644	0.99108	0.99166	0.9909
Station B	0.99651		0.99999	0.99872	0.99893	0.99865
Station C	0.99644	0.99999		0.99877	0.99899	0.9987
Station D	0.99108	0.99872	0.99877		0.99999	1
Station E	0.99166	0.99893	0.99899	0.99999		0.99998
Station F	0.9909	0.99865	0.9987	1	0.99998	

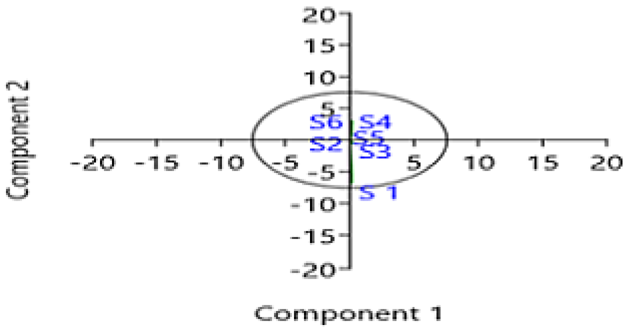

Figure 3. Principal Component Analysis (PCA) plot

sampling sites, possibly due to similar environmental or habitat characteristics along the river stretch. This uniformity can reflect stable biodiversity distribution patterns.

The principal components (PC1, PC2, and PC3) derived from data across six stations is given in Table 4. PC1 shows consistently high positive loadings across all stations, suggesting a shared dominant pattern. PC2 distinguishes Station A (strong negative loading) from Stations D–F (positive loadings), indicating variability along this axis. PC3 highlights a unique contribution from Station B (high positive loading) contrasting with negative or minimal contributions from others. These components together help reveal the main variance patterns among stations and suggest underlying environmental or spatial gradients influencing the dataset structure (Fig. 3).

Table 4. Principal Component Analysis

Stations	PC 1	PC 2	PC 3
A	0.4347	-0.80573	-0.17258
B	0.40334	-0.06805	0.8817
C	0.41464	-0.06121	-0.37678
D	0.39811	0.34564	-0.00061
E	0.40026	0.30895	-0.19068
F	0.39715	0.35708	-0.1204

DISCUSSION

The study on macroinvertebrate diversity in the River Kankai has provided valuable insights into the ecological health and biodiversity of this important river system in eastern Nepal. The research examines patterns and potential environmental influences on the River's ecosystem by analysing diversity indices, macroinvertebrate species distribution, and correlations across various sampling stations. The findings reveal a diverse assemblage of macroinvertebrates, predominantly comprised of Arthropoda, followed by Mollusca and Annelida. This dominance of arthropods is consistent with previous studies in freshwater ecosystems (Malla et al. 1978), which indicate that arthropods are often more adaptable to varying ecological conditions (Bhandari et al. 2018). The presence of molluscs and annelids highlights the relatively undisturbed nature of certain segments of the River. Spatial variation in diversity indices has revealed interesting trends across the six sampling stations. For instance, the decreasing dominance values from Station A (0.07083) to Station D (0.05828) suggest a reduction in ecosystem monopolisation, indicating increased species evenness and diversity in the mid-reaches of the River. However, Stations E and F show a plateau in dominance, implying stable but less dynamic species interactions downstream. Simpson's Index (1-D) and the Shannon-Wiener Index (H) consistently indicate increasing diversity from Station 1 to Station 6, peaking at Stations 5 and 6. This pattern reflects a balanced species distribution, potentially attributed to diverse microhabitats and lower anthropogenic pressures in the downstream areas. In contrast, Margalef's Index decreases from Station A (3.766) to Station F (3.265), suggesting reduced species richness due to cumulative impacts from habitat alterations, pollution, and environmental factors downstream. The observed patterns in macroinvertebrate diversity can be linked to varying ecological conditions along the river gradient. Upstream stations, such as Mahamai and Danawari, are situated in less disturbed mountainous regions with relatively pristine water quality, favouring a diverse assemblage of macroinvertebrates. In contrast, midstream and downstream stations like Kankai Ghat and Shivaganj are affected by anthropogenic activities, such as irrigation, cultural events, Chhath Puja, and annual fairs, which may contribute to habitat fragmentation and pollution, thus influencing species composition and richness. Moreover, the correlation matrix of diversity indices indicates a high degree of similarity among the stations, with correlations exceeding 0.99 in most cases. This strong uniformity may result from consistent sampling methodologies or overarching environmental gradients that affect all stations simultaneously. However, the slightly lower correlations involving Station A suggest unique ecological characteristics at this upstream site. The Principal Component Analysis (PCA) results further clarify the underlying factors driving diversity patterns. PC 1 represents a shared environmental gradient that reflects commonalities across all stations, with consistent loadings (ranging from 0.397 to 0.434) indicating overall ecological health or diversity. PC 2 captures site-specific influences, as its variability suggests it may reflect contrasting factors such as habitat structure, hydrological modifications, or pollution gradients. Finally, PC 3 emphasises unique contributions from specific indices (e.g., S2, with a high positive loading of 0.8817), highlighting the influence of localised ecological or sampling conditions.

The results of this study are consistent with earlier research conducted in Nepal and surrounding areas. Yadav et al. (1983) reported diverse macroinvertebrate communities in Taudah Lake, highlighting the dominance of molluscs and arthropods. Similarly, Sharma (1996) documented significant mollusc diversity in the Koshi River basin, indicating similar faunal assemblages across Nepalese rivers. However, the observed decline in species richness downstream of the River Kankai contrasts with findings from other systems, such as the Budhi Ganga River, where species richness often increases downstream due to habitat heterogeneity (Bhandari et al. 2018). The family Nepidae was commonly found at most stations along the River Kankai, similar to the findings of Upadhyay (2020) in the Setikhola watershed. These results were also supported by Shrestha (2008). According to Dévai (1990), the larvae of Diptera, Hemiptera, and Plecoptera play a crucial role in the circulation of nutrients in lakes and reservoirs, potentially influencing the rate of eutrophication through their feeding. These species are also known for their tolerance to various environmental conditions, contributing to their dominance in various habitats. Biological monitoring utilising macroinvertebrates has proven to be both accurate and beneficial compared to other organisms, as macroinvertebrates are highly sensitive to organic pollutants, are widely distributed, and are easy and cost-effective to sample. The riparian vegetation along the banks of the River may offer rich nutrient sources for macroinvertebrates (Patang et al. 2018). Gastropods can tolerate moderate pollution and are primarily found in lowland areas and ponds (Nesemann 2007). During periods of low water levels, macrophyte diversity tends to decrease, reducing the physical complexity of the aquatic environment and creating a more stressful habitat for algae and aquatic macroinvertebrates (Choi et al. 2014), potentially leading to lower diversity. This study emphasises the need for targeted conservation efforts in the River Kankai basin, including monitoring programs, pollution mitigation, habitat restoration, and community engagement in conservation initiatives.

CONCLUSIONS

This study presents a baseline assessment of macroinvertebrate diversity in the River Kankai, highlighting its ecological importance and the impact of environmental factors on biodiversity patterns. The predominance of NE-listed species, particularly among freshwater crabs and annelids, underscores the need for detailed taxonomic assessments and ecological studies to better understand the status and distribution of these understudied groups in freshwater ecosystems. The consistent correlation patterns reinforce the reliability of the diversity indices data. Macroinvertebrates have been adversely affected by water pollution and sand mining, which have led to habitat loss and increased vulnerability of various species. It is essential to minimise, monitor, and, when necessary, prohibit practices like bouldering, the direct discharge of industrial waste into water bodies, overfishing, and sand extraction to protect the River's aquatic flora, fauna, and overall ecological balance. These findings underscore the River's potential as a crucial resource for biodiversity conservation and a valuable model for studying riverine ecosystems in Nepal and beyond. Future research should integrate molecular and functional diversity analyses to gain deeper insights into the ecosystem dynamics and resilience of the River Kankai.

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REFERENCES

Allan, J.D. 1995. Stream Ecology – Structure and Function of Running Water. Chapman and Hall, London. 388 pages.

Anderson, C.B., Griffith, C.R., Rosemond, A.D., Rozzi, R. and Dollenz, O. 2006. The effects of invasive North American beavers on riparian plant communities in Cape Horn, Chile: Do exotic beavers engineer differently in sub-Antarctic ecosystems? Biological Conservation, 128, 467-474. https://doi.org/10.1016/j.biocon.2005.10.011

Baker, F.C. 1928. The fresh water Mollusca of Wisconsin. Wisconsin Academy of Sciences Bulletin, 70, 1-505.

Bhandari, B., Tachamo, R. and Sharma, S. 2018. Status, distribution and habitat Specificity of benthic macroinvertebrates - A case study in five tributaries of Budhi Ganga River in Western Nepal. Journal of Institute of Science and Technology Nepal, 23, 67-75. https://www.nepjol.info/index.php/JIST/article/view/22198/18936

Carter, J.L, Resh, V.H. and Hannaford, M.J. 2017. Macroinvertebrates as Biotic Indicators of Environmental Quality. Pp. 293-318. In: Lamberti, G.A. and Hauer, F.R. (Eds.). Methods in Stream Ecology, Academic Press, London. https://doi.org/10.1016/B978-0-12-813047-6.00016-4

Choi, J.Y., Jeong, K.S., La, G.H., Kim, S.K. and Joo, G.J. 2014. Sustainment of epiphytic microinvertebrate assemblage in relation with different aquatic plant microhabitats in freshwater wetlands (South Korea). Journal of Limnology, 73(1), 197-202. https://doi.org/10.4081/jlimnol.2014.736

Datta Munshi, J. and Datta Munshi, J.S. 1995. Fundamentals of Freshwater Biology. Narendra Publishing House, Delhi. 222 pages.

Devai, G. 1990. Ecological background and importance of the change of chironomid fauna in shallow Lake Balaton. Hydrobiology, 191, 189-198. https://doi.org/10.1007/BF00026052

Lucadamo, L., De Filippis, A., Mezzotero, A., Vizza, S. and Gallo, L. 2008. Biological and chemical monitoring of some major Calabrian (Italy) Rivers. Environmental Monitoring and Assessment, 146, 453-471. https://doi.org/10.1007/s10661-007-0091-7

Loeb, S.L. and Spacie, A. 1994. Biological Monitoring of Aquatic Systems.Lewis Publications, Boca Raton, Florida. 381 pages.

Mahato, M. and Yadav, U.K.R. 1984. The composition of benthic macro invertebrates of two ponds of Mahottary District, Nepal. Journal of Natural History Museum, 8, 79-88.

Malla, Y.K., Kapoor, V.C., Tamrakar, A.S. and Baidya, K. 1978. On a collection of aquatic insectsof Kathmandu valley. Journal of Natural History Museum, 2, 1-19.

Nesemann, H., Sharma, S., Sharma, G., Khanal, S., Pradhan, B., Shah, D.N. and Shah, R.D.T. 2007. Aquatic invertebrates of the Ganga River System, Conch Books, Kathmandu, Nepal. 263 Pages.

Patang, F., Soegianto, A. and Hariyanto, S. 2018. Benthic macroinvertebrates diversity as bioindicator of water quality of some rivers in East Kalimantan, Indonesia. International Journal of Ecology, 2018, 5129421. https://doi.org/10.1155/2018/5129421

Pennak, R.W. 1953. Freshwater Invertebrates of the United States. The Ronald Press Company, New York. 792 pages.

Rai, K.R. 2004. Ecological distribution of *Cyclemys oldhamii* (Grey, 1863) from Nepal. Our Nature, 2, 7-13. https://nepjol.info/index.php/ON/article/view/317/309

Sharma, U.P. 1996. Ecology of the Koshi river in Nepal-India (North Bihar): A typical river ecosystem. Pp. 92-99. In: Jha P.K., Ghimire, G.P.S., Karmacharya S.B., Baral S.R. and Lacoul P. (Eds.). Environment and Biodiversity: In the Context of South Asia, Ecological Society (ECOS), Kathmandu, Nepal.

Shrestha, A.B. 2008. Climate change in the Hindu Kush-Himalayas and its impacts on water and hazards. Asia Pacific Mountain Network Bulletin, 9, 1-5.

Subba, B.R. and Ghosh, T.K. 2008. Report on some terrestrial molluscs from different regions of Nepal. Journal of Natural History Museum, 23, 78-81. https://doi.org/10.3126/jnhm.v23i0.1842

Upadhyaya, K.D. 2020. Aquatic Phytodiversity and Macro-invertebrates in Water Bodies of Setikhola Watershed, Kaski, Nepal. Master thesis submitted to Central Department of Botany Institute of Science and Technology, Tribhuvan University, Nepal.

Yadav, U.K.R., Ghimire, P.S. and Amatya, R. 1983. Biological investigation of Taudah Lake, Kathmandu Journal of Natural History Museum, 7, 2-14.

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