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A review on: Insects as bioindicators for an ecosystem and key species in trophic level

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Abstract

Freshwater Rivers are essential to the urban environment and help people in many ways, both directly and indirectly. Insects are a common and very diverse group in aquatic systems. They serve as model organisms to analyze the structure and dynamics of freshwater ecosystems and as a source of food for vertebrates and invertebrates of much aquatic systems.The presence of insects in aquatic environments can reveal various environmental variables within the water. An interesting class of creatures, insects are involved in decomposition, energy transfer, cycling of nutrition and interaction of prey-predator. Insects are important because of their diversity, ecological importance, and impact on agriculture, human health, and natural resources. These contain about 58% of the world's known biodiversity. They are essential for the stability and functioning of both terrestrial and aquatic ecosystems. Insects play an important role in our daily lives and have a variety of impacts on human well-being. Along with this, many unknown species are also disappearing from their original habitats across the world as a result of human interference. Aquatic insect reproduction is greatly affected by heavy metals, which reduce biodiversity and reproductive success. According to research, exposure to metals like cadmium, copper and zinc can disrupt the reproductive process of many aquatic species. Despite the fact that heavy metals pose a major threat to the reproduction of aquatic insects, some research suggest that certain species may be resilient, pointing to there is a need for further exploration into adaption processes.

Keywords: Aquatic insect; Heavy metal; Environment; Decomposition; Reproduction; Exploration

1. Introduction

Aquatic ecosystems isdiverse and constantly changing structuresthat surround bydiversity of environments like freshwater and marine habitats.To have the typical quality of recycle the nutrients, filter water, and provide essential habitats for diverse flora and fauna, while also offering recreational opportunities for humans (T., V., Ramachandra., et. al. 2005). These ecosystems are classified based on criteria such as depth, water flow, and salinity, and they include organisms like algae, aquatic plants, and various animal species (Ololade, Olatunji. (2020).However, aquatic ecosystems face significant threats from anthropogenic activities, including pollution,habitat reduction, pollution from residential and industrial sources, land use changes andEnvironmental Variability, who has taken the lead to declines in biodiversity and ecosystem functionality (T., V., Ramachandra., et. al. 2005).As an example, freshwater ecosystems are especially susceptible to land use changes and eutrophication, while marine environments are increasingly impacted by rising temperatures and overexploitation. Effective management and restoration efforts are crucial to reduce these impacts and preserve the ecological integrity of aquatic systems (Ronald, B., et. al. 2023).

Aquatic insects play a crucial role in ecosystem biodiversity by serving as bio-indicators for assessing water quality, contributing tocycling of nutrients, primary generation, and breakdown, and materials translocation in freshwater ecosystems (Khaghani et. al. 2022).They serve as linkages between aquatic and terrestrial ecosystems and facilitate the cycling of nutrients and energy through food webs, making them essential parts of both aquatic and terrestrial food chains (Starr, S.M.; Wallace et. al 2021). Aquatic insects also have a role in the purification of water, which emphasizes

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their importance in preserving the natural equilibrium of freshwater ecosystems flora and fauna. By consuming and storing resources in their body tissues, these insects play a crucial part in the bio-geochemical cycle and contribute to consumer-driven nutrient dynamics (Suhaila Ab Hamidet. al. 2023). In freshwater habitats, true flies (Diptera) are especially relevant since theyfunction as biological control agents, ecosystem engineers, and water quality indicators. With over 13,000 identified species, aquatic insects like water beetles are among the most diverse animal groups found in freshwater environments and are also among the most prevalent in the world (R. R.Kulkarni et. al. 2020).Their abundance and diversity make them essential for maintaining ecological balance, supporting overall aquatic environmental health, and contributing significantly to the economic and aesthetic value of aquatic biodiversity.Aquatic hymenoptera also interact with water bodies and can offer insightful information on biological control and human life effects. They are abundant and diverse, including more than 500 species in Indian wetlands alone, mainly belonging to orders such as Ephemeroptera, Odonata, and Trichoptera(Ghazal Tashakori et. al. 2022).

Aquatic insects are vital components of freshwater ecosystems approximately 45,000 insect species occupy these environments, with about 3-5% intimately related to aquatic environments with Hemiptera, Odonata, and Coleoptera being predominant orders in various studies(Raman, Jasrotia2024).Insects serve as indicators of water quality, their diversity consider the ecological health of aquatic systems, influenced by food availability, habitat +condition, presence of pollution-tolerant species orten domination in degrade ecosystem and the absence of sensitive taxa indicate decline water quality(S.O., Adeleke., 2024) (Jyothy, Lakshmi 2021).In freshwater habitats, true flies (Diptera) are particularly significant since they function as biological control agents, ecosystem engineers, and water quality indicators. With over 13,000 identified species, aquatic insects like water beetles are among the most diverse animal groups found in freshwater environments and are also among the most prevalent in the world (R. R.Kulkarni et. al. 2020).Their abundance and diversity make them essential for maintaining ecological balance, supporting overall aquatic environmental health, and contributing significantly to the economic and aesthetic value of aquatic biodiversity. Aquatic hymenoptera also interact with water bodies and may provide insightful information regarding biological control and human life effects. They are abundant and diverse, has approximately 500 species discoveredin Indian wetlands alone, mainly belonging to orders such as Ephemeroptera, Odonata, and Trichoptera(Ghazal Tashakori et. al. 2022).A study in Bangladesh shown identified 4134 insect's species across 18 genera, with Hemiptera include 74.41% of the total (Thamia, Siddiky 2024).Similarly, in Nigeria, Hemiptera view as for 90.91% of collected specimens, its dominance is considered in disturbed environments (S.O. et. al.2024).

Aquatic insects also facilitate energy transfer between aquatic and terrestrial ecosystems(Vivek, Hanmantrao, et. al.(2023).However, anthropogenic activities, such as industrial pollution have significant threats to their diversity and the overall health of aquatic ecosystems(Raman, Jasrotia2024) (Vivek, Hanmantrao et. al. (2023). Effective conservation strategies are essential to mitigate these impacts of urbanization and pollution on their diversity and preserve the ecological balance that aquatic insects help to maintain(Raman, Jasrotia 2024) (Fatima, Alkhayat et. al. 2024).

It has been determined that urbanization is a major threat to aquatic insects in wetlands, with habitat loss, fragmentation, and alterations in environmental factors affecting their biodiversity (Javier muzon et. al. 2019). Additionally, the heavy metals' bioaccumulation in aquatic insects from streams in the Brazilian Cerradodemonstrates the effects of human activity on these organisms and their potential as biomonitoring tools. (Renata de Moura Guimarães Souto et. al. (2017). Human activities can impact aquatic insect diversity, as seen in a study near a gold mine in Central Sulawesi, where the diversity of aquatic insects tended to decrease downstream, with higher diversity observed in areas with elevated dissolved oxygen levels. Understanding aquatic insect diversity is essential for assessing ecosystem health, water quality, and overall biodiversity within aquatic settings (Hasriyanty et. al. (2022).

Heavy metals have also serious and long-term effects on aquatic insects, affecting biodiversity, population dynamics, physiology and ecological roles. According to research, heavy metals like lead, mercury and chromium have a significant impact on the aquatic environment, reducing insect populations and biodiversity. Heavy metal contamination alters nutrient cycles and biological interactions, causing widespread ecosystem disruption (Sameer, Ghanem et al. 2023).

Heavy metals impact water quality, making aquatic insect important markers of environmental health. Metal concentrations have been linked to decreased variety in aquatic insect genera, including Coeleoptera and Odonata(Sazia, Tabassum et. al. 2024).Heavy metal concentrations have the potential toseasonal oscillations in insect populations, such as Limnodrilus cervix, which saw large shifts in abundance due to copper toxicity.Acute toxicity Experiments demonstrate that even at modest doses of lead can significantly influence aquatic insect longevity, with an LC50 value of 0.03 mg/L for L. cervix(Waqas, Ahmed 2024).Heavy metals can induce oxidative stress and DNA damage in aquatic animals, compromising their survival and reproduction (Krishnamoorthy Santhosh et. al. 2024). Heavy metals bioaccumulate in aquatic insects, causing hazards to their populations and the food chain. These insects serve as prey

of higher trophic levels(Krishnamoorthy Santhosh et. al. 2024).Insect pests exposed to heavy metals may acquire cross-tolerance to pesticides, complicating pest control techniques(JiYoon, Lee et. al. 2023)

Heavy metal exposure causes cross-tolerance in pests to pesticides. The priming effect of heavy metal exposure on enzymes involved in pesticide metabolism (Shanchun, Yan et. al. 2024).

The influence of lead, chromium, cadmium, zinc, and mercury on aquatic life was reviewed. Heavy metal pollutants are harmful to aquatic organisms(Sourav, Das. 2024).

Heavy metal contamination has a deleterious impact on Clarias batrachusbehavior and survival rates. Mitigation methods are critical for species and aquatic ecosystems' well-being(Shivani, Singh et. al. s2023).

Heavy metals were detected in aquatic invertebrates investigated single/mixed forms, combinations with other contaminants, and environmental influences(Ha-Cheol, Jeong et. al. 2023).

Heavy metal pollution affected the composition of the gut microbial community. The microbial diversity of pygmy grasshoppers was impacted(Xiao-Dong, Li., Lei, Xin et. al. 2021).

Insects are effective bioindicators for detecting environmental contamination. Pollution impacts insects both directly and indirectly, depending on their trophic position (Rasy, Fayaz, Choh, Wani et. al. 2024).

Under the influence of mining activities were discovered. Rivers have significant metal concentrations, however there is a wide variety of macroinvertebrates observed. The alkalinity and hardness of rivers provide protection for aquatic biota (Axel, Eduardo, Rico-Sánchez et. al. 2021).

Invertebrates are good markers of environmental contamination. Metal contamination's impact on ecological disturbance is highlighted (Samir, Ghannèm et. al. s2023).

Metal levels have a profound impact on macroinvertebrate communities. Changes in community composition suggest metal consequences in tropical streams (Taurai, Bere et. al. 2016).

Water insect diversity is connected to heavy metal levels and water factors. Rhagovelia, Rheumatogonus, and Paraplea are frequent and important genera under research (Nur, Adibah, Mohd, Ishadi et. al.2014).

Contaminated aquatic creatures can harm human health, emphasizing the importance of proper management measures.While heavy metal pollution poses a serious threat to aquatic insect populations, some species have adaptive responses that may mitigate the effects of these stressors. This resistance demonstrates the complexities of ecological interactions in contaminated areas.While heavy metal pollution poses a severe danger to aquatic insect populations, According to certain study, certain species may evolve over time, demonstrating a complex interplay between pollution and ecological resilience.

2. Review of literature

Mayflies are hemimetabolous insects that live on land as adults and in water as nymphs. Nearly all freshwater ecosystems on the planet are home to nymphs. The most diversified wildlife lives in warm lotic settings. (Williams &Feltmate (1992).

Sanjay, S., Bapat, et. al. (2001)Pune city's molluscs and aquatic insects were discovered greater variety in less contaminated waterways. Species of molluscs declining as a result of pollution and habitat loss.

According to Resh &Carde, (2003)more over half of all known organisms are bugs, with over a million species now recognized. Approximately 50,000 insect species, or 2% of all species, have aquatic stages.

J. Reese., J. Voshell., (2005) maintaining the aquatic biodiversity in America. The conservation and variety among aquatic insects in North America is home to around 8,600 aquatic insects species.Insects comprise 74% of animal species.

A(2006) review by Duc Huy Hoang and Yeon Jae Bae compared the aquatic insects diversity in a tropical vietnamese stream to that of a temperate Korean stream discovered attractive species: compared to gapyeong stream having 133

species belongs to 98 genera of 51 families and 8 orders), dak pri stream had roughly twice as many aquatic insect taxa with 268 species primarily undescribed belongs to 230 genera of 91 families, and 9 orders). the main orders of aquatic insects with high taxonomic richness were Coleoptera, Trichoptera, Ephemeroptera, and Diptera, Odonata, and Hemiptera also contributed to the higher level of aquatic insect diversity in dak pri stream.

M., D., Moroz., et al. (2006) survey on aquatic insects (insecta,plecoptera, ephemeroptera, odonata, and trichoptera) of the rivers in the Berezinskii biosphere reserve were found 108 species of aquatic insects from 4 orders found. some species recorded in Belarusand Europe for the first time.

Sankarappan, Anbalagan. et. al.(2006)survey on seasonal variation of diversity and habitat preferences of aquatic insects along the longitudinal gradient of the Gadana river basin, south-west ghats (India) were found 4th order stream had highest insect diversity. South-West monsoon showed highest richness and abundance.

Archana, Sharma., et. al. (2008) survey at Garhwal Himalayas in Chandrabhaga River on aquatic insect diversity, correlated with physico-chemical variables. Trichoptera and ephemeroptera had highest annual contributions.

Andrew, M., R., Bennett. et. al. (2008) survey on global diversity of hymenopterans (hymenopterainsecta) in freshwater. Were found 150 aquatic hymenoptera species recognized from 11 families. aquatic behaviour evolved independently at least 50 times.

A survey on the global diversity of freshwater dipteran families (insectadiptera) apart from the simulidae, culicidae, chironomidae, tipulidae, and tabanidae was conducted by Rüdiger et al. in (2008).19 dipteran families were discovered to have global diversity in freshwater habitats.

Antonio, Di, Sabatino., et. al. (2008) survey on global diversity of water mites (acari, hydrachnidia; arachnida) in freshwater were found global water mite diversity: 6,000 species, 57 families, 81 subfamilies. regions with highest species richness: palaearctic, neotropical, nearctic.

F., C., De, Moor., et. al. (2008) survey on global diversity of caddisflies (trichoptera: insecta) in freshwater were found uneven distribution of trichoptera species across different regions. major phylogenetic differentiation in trichoptera occurred during jurassic.

Leonard, C., Ferrington. et. al. (2008) survey on global diversity of non-biting midges (chironomidae; insecta-diptera) in freshwater. were discovered 339 genera and 4,147 species are aquatic in immature stages. greatest richness in palaearctic and nearctic regions.

Manfred, A., et. al. (2008) there are around 18,000 aquatic coleoptera species in freshwater worldwide, according to research on the diversity of these insects. currently, 70% of aquatic coleoptera species have been described.

Matthew, R., et. al. (2008) survey on global diversity of dobsonflies, fishflies, and alderflies (megaloptera; insecta) and spongillaflies, nevrorthids, and osmylids (neuroptera; insecta) in freshwater. were found 328 species of megaloptera and 73 species of aquatic neuroptera. there are new species found and the variety of aquatic neuropterids is not fully understood.

Polhemus, John T., et al. (2008) an overview of the diversity of genuine bugs (heteroptera: insecta) in freshwater environments worldwide. 4810 genuine species group taxa were discovered, of which 4,656 live in freshwater. there are 1,100 species still uncharacterized.

Wolfram, Mey., et. al. (2008) survey on global diversity of butterflies (lepidotera) in freshwater were found acentropinae have 737 described species of 50 genera worldwide.a few species have aquatic larvae sensitive to water quality.

At a pond in the town of Midnapore, west bengal, India, sarmistha, jana., et. al. (2009) studied the aquatic insect's variety and social organizationand discovered that there are 20 species total. odonata is the most prevalent category in the sample collection, accounting for 54% of the total. the presence of coleoptera also indicates a broad species composition.

Shailendra, sharma.,et. al. (2010) survey on biodiversity and abundance of benthic macroinvertebrates commiunity of kishanpura lake, Indore (M.P.) India. Were found identified 7 oligochaeta species, 3 hirudinea species, and 3 gastropoda families. Found 2 bivalvia species, insecta species, and crustacea species.

Rabindra Hazarika & Mrigendra M. Goswami (2010) overview at Assam in Guwahati were found 12 genera and 14 species belongs to 7 family among which Nepidae family is most diverse in number.

Rajnish Kumar Sharma and Nirupma Agrawal (2012) review at surhatal of Ballia (U. P.) in faunal variety of aquatic insects were found 29 species of a freshwater insect belonging to 14 family of 4 orders and 20 genera where 29 species was identified.

A survey on the variety and abundance of aquatic insects inside the western ghats of India was conducted in (2013) by K, J, Sivaram Krishnan et. al. journal of the Indian institute of science, 4533 water insects of 72 species, 45 families, and 10 orders were discovered in the western ghats, demonstrating a high degree of variety across ecological gradients and taxonomic levels.

B, K, Baruah., et. al. (2013) 5 orders of aquatic insects were identified in the flood plain wetland of Kapla Beel in the Barpeta district of Assam, India. the majority of all insects are classified as hemiptera.

It was found that Joydeb Majumder et al. (2013) has reviewed the flora and variety of aquatic insects in the urban freshwater lakes of Tripura. 2159 individuals in all, representing 31 species from 23 genera, 15 families, and 4 orders, were identified. Maximum 30 species and 1191 individuals of aquatic insects were recorded in the vegetation-rich Maharaja Bir Bikram College Lake; minimum 11 species and 215 individuals were recorded in the vegetation-poor Laxminarayan Bari Lake. Insects from the orders Hemiptera (32.26%) and Odonata (32.25%) have higher species richness, followed by Diptera (9.68%) and Coleoptera (25.81%).

The distribution and variety of aquatic insects in Kerala's Vellayani Lake were surveyed in 2013 by U., G., Abhijna, et al. Vellayani Lake is home to 60 variedspecies of aquatic insects.

Jenila, G. J, C. Radhakrishnan, Nair et. al. (2013) survey on biodiversity of aquatic insect population in two permanent ponds of kanyakumari district were found survey found 25 species from 11 families and 4 orders. aquatic insects indicate water quality in the environment.

Ampon, Payakka., et. al. (2014) survey on aquatic insect's biodiversity and water quality parameters of receiving water body were found a 4,257 individual of aquatic insect belongs to 12 families of 6 ordersWere also found aquatic insect abundance correlated with alkalinity and dissolved oxygen. signs of water quality deterioration observed in physicochemical analyses.

M., Bhubaneshwari, et. al. (2014) survey on diversity, abundance and species organization of water beetles (coleoptera: dytiscidae, hydrophilidae and noteridae) from the loktak lake of Manipur, North East India. 15 species of water beetles from 3 families recorded. Site had the highest species diversity (5.25 species).

Vasantkumar, B., et al. (2014) survey on physico-chemical and aquatic insect's diversity of pond ecosystem in karwar, India. Were found 15 aquatic insect species from 6 orders found. Coleoptera was the most abundant order in the study period.

An overview of the biodiversity of aquatic insects from two orders, seven families, and twelve species is provided by Mansoreh et. al. (2014) in their study of the Zayandehroud river and its branches in the Iranian province of Isfahan. The orders diptera (92.31%) and coleoptera (7.69%) were found.

Carla, Bender et. al. (2014)was survey on aquatic insect communities from highland streams in southern Brazil: their diversity and ecological characteristics and found 5320 individuals collected from 18 families 52 genera with high diversity of ephemeroptera, plecoptera, trichoptera, and coleoptera communities found in montane streams in Southern Brazil.

11,153 distinct insects from 64 families, of 9 orders, were found byWitwisitpongManeechan and Tseng on Prommi in their (2015) from 3 different streams in Western Thailand's Mae Klong Watershedstudy on the richness and range of aquatic insects. Trichoptera was the most diverse group of insects found in these three streams in terms of quantity gathered. Ephemeroptera, hemiptera, odonata, coleoptera, diptera, plecoptera, megaloptera, and lepidoptera were the next most diverse groups. About 54% of the sample is composed of members of the trichoptera and ephemeroptera groups.

Nasiruddin muniraet. al. (2015)Aquatic insect diversity and abundance in two water bodies on the campus of Chittagong university were surveyed. were discovered from the pond and lake, 4,406 aquatic insects in all were gathered. The most prevalent class of insects were represented by odonate species.

Swetapadma, Dash. (2015) survey on aquatic insect diversity of baitarani estuary of Odisha were found hemiptera, diptera, coleoptera, odonata in baitarani estuary. Low diversity compared to freshwater; influenced by salinity and water current.

(2015) Srivastava, D. the ecological properties of the zooplankton fauna in Churu, Rajasthan, India's desert pond ecosystem. Found fauna composed of zooplankton: rotifers, arthropods (crustacea, insecta), and protozoans. Limnology, physical-chemical: well-oxygenated, alkaline, shallow, and murky water.

Dharitri, Choudhury., et al. (2015) survey on aquatic insect community of deepor beel (ramsar site), Assam, India, were found 31 species from 18 families of 5 orders were recorded. Hemiptera is the largest order followed by coleoptera.

In (2015), Kiranbala and colleagues conducted a survey on the diversity of water insects in keibullamjao national park, a protected region located in Manipur, North East India. Asia-Pacific journal of entomology the water insect study conducted in keibullamjao national park found 23 species, 12 families, and 3 orders, suggesting a disturbed ecology with limited diversity and heavy metal pollution.

Jaiswal, Deepa (2015) aquatic entomofauna Hyderabad's diversity of insects and beetles was discovered there are 31 species of aquatic beetles and 14 hemiptera species known. An organized key is offered for simple entomofauna identification.

In their review published in (2016) atTanzania's Mbeya University of Science and Technology, Fredrick Ojija et al. found that the most abundant insect groups were orthoptera (19.123%), hymenoptera (36.150%), and coleoptera (30.686%), while the least abundant groups were diptera (0.889%) and mantodae (1.271%).

Kevin, j., collier., et al. (2016) survey on conservation of aquatic invertebrates: concerns, challenges and conundrums. Aquatic conservation-marine and freshwater ecosystems were found 30-34% of aquatic invertebrates are data deficient. Threats include pollution, overexploitation, habitat destruction, and climate change.

Aakriti, Chauhan., et al. (2016) survey on the range and variety of aquatic insects in himachalpradesh, India was found 31 species from 18 families of 5 orders were recorded. Hemiptera is the largest order followed by coleoptera.

Hv, Wanjari. et. al. (2016) survey on diversity of aquatic birds of Ekburji reservoir, Washim, M.S. India. were found 41 species of aquatic birds were recorded in Ekburji reservoir. The recorded species included residential breeders, winter migratory, and residential migratory species.

In two freshwater streams in the southern western ghats of India, T.Kubendran and MRamesh (2016) review on the the makeup and range of aquatic insect populations in relation to water quality was discovered. 7473 water insects in all, divided into 21 genera and 17 families across 8 orders. the two streams that contained the most prominent groups were ephemeroptera, plecoptera, and tricoptera (EPT).

In their analysis of the ecological studies of soil fungi in Mehmara, Chhatagrh, Kotani, and Rajnandgaon road in Shivnath river, Durg, Chhattisgarh, Shivani Sharma and Ashish Saraf (2016) discovered 17 genera, 24 fungal species, 21 genera, 49 species, 18 genera, 32 species and 16 genera.

Govindasamy Ponraman et. al. (2016) a review was conducted on the diversity of water insects in South India's irrigated rice fields, specifically focusing on mosquitoes. 266556 aquatic insects in all were gathered. Out of which 35 morphospecies were recognized. Naturally, predators and collectors coexist to limit mosquito larvae.

When InnifaHasan et. al. (2016) reviewed the aquatic insect population's biodiversity in three permanent ponds in Guwahati, Assam, India, they discovered 25 distinct species from 6 orders and 13 families. With fifteen species, the order hemiptera has the most, followed by coleoptera (four species) and other orders like odonata (two species), hymenoptera (one species), ephemeroptera (one species), and diptera (two species). The most dominating group was hemiptera, whereas the least dominant group was hymenoptera.

10 families of 4 orders with 12 genera, and 12 species of aquatic insects were discovered by arundhatigogoi and susmitagupta's (2017) survey at North East India Assam on aquatic insect ecosystem of theBrahmaputra River close to the Dibru Saikhowa National Park. Across all locations and seasons, the order hemiptera had the highest density.

Ankit, Kumar. et. al. (2017) survey on diversity of macrozoobenthos in dudhi river- a tributary of river Narmada in the central zone, Indiawere found macrozoobenthos of which 26 taxa recorded from dudhi river. Arthropods dominant in taxonomic composition (77%).

A survey conducted in (2017) by Purnam deka et al. on the variety of aquatic insects in a selected water body in Guwahati, Kamrup district, Assam, indicated that there are 26 genera, 17 families, and 5 orders of aquatic insects. The most prevalent order in all of the aquatic bodies under investigation was Ephemeroptera.

E. Sankarganesh (2017) review on Insect Biodiversity the Teeming Millionsnearly 63,760 species of insect species in India, about 21,166 species are endemic.

According to the journal of marine science: research &development in a summary of the variety of aquatic insect species in the karaj river in central Iran by Hassan Vatandoost et. al. (2018) found 436 aquatic bug specimens were gathered. the most common family was hydropsychidae.

Review by Sadguru, Prakash (2018) on the aquatic insect diversity in the wetland of semara taal, district of siddharthnagar, U. P. discovered 20 distinct species of water insects, with the majority of them being hemipteran, odonata, and coleopteran insects.

An overview of the aquatic insect ecology in the situ gede system, Bogor, Indonesia, as an indicator of water quality assessmentby WindraPriawandiputra et. al. (2018) and discovered that there are 598 members of 14 families of water insects, with the most prevalent genera being corixidae and notonectidae. For evaluating the quality of water, they function as bio-indicators.

In India at subansiri river basin floodplain wetland, Budhin, Gogoi et al. (2018) observed faunal diversity of cladocera (crustacea: branchiopoda) with notes on biogeographically important species were found with 55 cladocera species.

Ramasubramanian, Ravichandran., et. al. (2018) survey on diversity and habitat use of odonates in cauvery basin, Tamilnadu, India.were found 20 species of dragonflies were recorded during the study. majority of the species belong to the family libellulidae.

Shimantini, Borkataki., et. al. (2018) survey on aquatic insect fauna of majuli river island of Assam were found 48 aquatic insect species from 6 orders and 20 families. Odonata most dominant order with 23 species.

SrimoyeBasu et. al. (2018) survey on morphological and molecular characterization of predatory aquatic and semi aquatic bugs of India were found identical 8 species of aquatic and semi-aquatic hemiptera. Used morphology and coi gene forspecies identification.

Srimoyee, Basu., et. al. (2018) survey on water bugs (insecta: hemiptera: heteroptera) of Himalayan and Sub-Himalayan regions of west Bengal, India were found 61 species from 14 families documented in West Bengal. 11 new species, 15 new species state records, 1 new species India record.

Abhilash HebbalR et. al. (2019)was found in their survey in two freshwater lakes varuna lake and dalvoy lake of mysore district of karnataka total 31 species from 6 orders of 19 families. Coleopterans are most abundant families showed 57% in varuna lake whereas hemipterans families with 66% are most abundant in dalvoye lake.

Babunath R., (2019) review at Tamil Nadu in Amaravathi River were found 830 aquatic insects' where 662 approximately 79.76% are belongs to hemiptera.

According tojoydeep das et. al. (2019) summary of the seasonal change of aquatic hemiptera and odonata in the kangsabati river in west Bengal, hemipterans are the most prevalent, accounting for 78.60% of the total.

Bw, Adu., et. al. (2019)Three insect orders were discovered in the water quality characteristics and aquatic insect diversity of the Ahoo stream in southwest Nigeria: diptera, odonata, and hemiptera. The most common species of chironomus is linked to contaminated water.

In their assessment of the variety and relative abundance of the insect fauna in Wukari, Taraba state, Nigeria,OkrikataEmmanuel et. al. (2019) discovered 4501 unique insects from 34 families of 9 orders, comprising 77 species. within the entire sample, 44.41% are made up primarily of coleopterans.

Joao Antonio CyrinoZequi et. al. (2019) studiedin pasture stream in northern parana, Southern Brazil in 3 streamto analyze the the composition of aquatic insect colonies with emphasis on the groups of indicators of good water quality were found a total of 1323 individuals were collected, being chironomidae (diptera) the most abundant taxon.

A survey on the species composition, abundance, and aquatic insect diversity was conducted by Michel, Laurince, Yapo, et al. (2020) in two dam-created lakes in Korhogo, Koko and Natiokobadara. A total of 6 orders, 23 families, and 55 taxa were identified, with heteroptera, odonata, coleoptera, and diptera predominating.

In their review published in (2020), Aman Verma and Manoj Kumar Arya noted that habitat destruction at the Pancheshwar dam site on the river Mahakali in the central Himalaya contributed to the biodiversity of entomofauna. There were 140 species and 5908 individuals reported across 7 insect orders, with the lepidoptera being the most species-rich (67.85%) and abundant (47.61%) group of insects with 10 species of butterflies that are legally protected in India.

A study on the contribution of aquatic insects to the enhanced biodiversity of a freshwater reservoir was conducted by R., R. Kulkarni and S.B. Zade in 2020. 16 species of water insects from 14 families and 4 orders were detected in the study published in the environment conservation journal in Ramala, Chandrapur, Maharashtra. the study also showed significant diversity and seasonal population fluctuation.

Dipterans make up the majority of the insect diversity, with a total of 603 species from 10 orders and 38 families discovered in the neighboring Raipur, Chhattisgarh, according to Prerna Prakhar et. al.(2020) survey in insect diversity in various habitats.

Research by K., Sharma et. al. (2020) on the aquatic insect variety in the Gwalior district's Ramaua reservoir (M.P.). In this work, the study revealed 24 different aquatic insect species in the Ramaua reservoir near Gwalior. Lepidoptera was the least diverse order, whereas hemiptera and diptera were the dominating ones.

Sadguru Prakash et. al. (2020) survey on aquatic insects diversityintwo fresh water bodies of Balrampur district (U.P.), India in relation to physico-chemical characteristicswas found the insect fauna of these two freshwater basins was diverse, with 32 genera representing 20 families and 6 orders. the order hemiptera (15 genera) dominated the aquatic insects gathered from both freshwater bodies, followed by the orders odonta (7 genera), ephemeroptera (3 genera), diptera (3 genera), coleoptera (2 genera), and trichoptera (2 genera).

Shekh Alisha and colleagues (2020) according to a review of the diversity of chalcidids (hymenoptera), the highest diversity of chalcidids was identified in the natural vegetated plains of california, as well as in other agro-climatic zones of the state.

Aquatic insect diversity and water quality assessmentof a tropical freshwater pond in Benin city, Nigeria, by Komolafe, Bo,Imoobe, (2020) was discovered ten insect taxa, or 103 individuals in two orders, were identified in the study. Of these orders, there were seven species in the hemiptera and three species in the coleoptera.

Jyothy, lakshmi., et. al. (2021)an examination of aquatic insects as a means of tracking the condition of the riverine ecology, with a focus on Killiyar, Thiruvananthapuram, Kerala, Indiawere found 29 families of insects identified for bioassessment. high contamination in midstream and downstream segments.

Majid ali et. al. (2021) was survey on diversity and ecological aspect of aquatic communities of insects in three different sites in dankani river of Bastar region of Chhattisgarh in which at Darbha-Jheeram valley of the dankani river has seen a total of 252 individual from 13 families. the cordulegastridae family had the highest diversity (71%). Teknar of dankani river reported a total of 234 individuals from 15 families, with the cordulegastridae family having the highest diversity (58%). Lower bridge, Dantewada of the dankani river, showing a total of 93 individual from 19 families were spotted. the cordulegastridae family had the highest diversity (41.75%).

Nisreen Husain et. al. (2021) conducted an entomological survey in the Bastar region of Chhattisgarh Characterization of some of the butterfly species of Papilionidae species were found 118speciesin which many are threatened and many are near extinctness.

Farha Naz, (2021) review at Udaipur, Rajasthan on aquatic insect diversity were found 12 family of 6 orders having 24 species of insect.

Shivaraju et. al. (2021) survey on faunal diversity in Karnataka state at durgadahalli lake of tumakuru, India werefound freshwater ecosystem importance and arthropods in the lake.

K. Elango, G.et. al. (2021) review on importance and conservation of aquatic insect diversity were found 8600 insects species individual belong to 150 families of 12 order.

Abdul, Salam, et. al. (2022) conducted a survey on the varietyof water insects in the euphrates river and discovered that chironomidae larvae were the most abundant aquatic insects. zygoptera nymph species were the most frequent in the first location.

A survey of the global biology on aquatic insects in the order hymenoptera was conducted by Ghazal et. al. in (2022).According to study published in the journal of marine science study and oceanography, there are 150 species of aquatic hymenoptera known to exist, belonging to 11 families including the chalcididae, eulophidae, and mymaridae, which have adapted to freshwater habitats.

In central sulawesi, hasriyanty et. al. (2022) survey on the variety of aquatic insects around a gold mine revealed 23 species from 7 orders and 14 families, with the Ephemeroptera group being the most prevalent.

Marina, Vilenica., (2022) were survey on aquatic insect's biodiversity and found over 60% of freshwater species diversity. About 130,000 extant species of aquatic insects have been described.

Ramnikantkumar and kritikant (2022) review on biodiversity and distribution of insects were found 9 taxa belonging to hemiptera (true bugs) 62% coleopteran (beetles) 33%whileodonata (dragonflies) 5% collected.

In 2023 Md, AminulIslam were survey on heterogeneityand excess of aquatic insect fauna in an urban freshwater lake, Bangladesh Hatirjheel lake were found 11 species, 31 genera, 20 families of 5 order and dominant species is micronectahaliploides.

Nur Atirah Hasmi et. al. (2023)was survey on preliminary study in the quantity of aquatic insects in sungaisst, tamanneharapahang, malaysia and found total 731 individuals of aquatic insect's diversity belong to 19 families of 7 orders. Ephemeroptera is the most abundant about 49.5% of total sample collected.

Using the biological reserve of Sidi Boughaba and the Merja of Fouarat as case studies (gharb plain, Morocco), M., Slim., et. al. (2023) reviewed the biodiversity of aquatic heteroptera in relation to physico-chemical parameters. They identified two groups of aquatic heteroptera species: steroidal species that are sensitive to physicochemical factors in the environment.

Anshuman, pati., et. al. (2023) survey on the heterogeneityof macroinvertebrates in suburban and rural aquatic bodies of West Bengal were found high heterogeneityof macroinvertebrates found in suburban and rural areas. Implications for Effective Vector Control Strategies in West Bengal.

Rita, deb., et. al. (2023) survey at Navegaon national park, Maharashtra, India on diversity of aquatic beetles (insecta: coleoptera) were found 19 species of aquatic beetles from 13 genera recorded. family dytiscidae was the most species-rich group.

M. Danswrang Basumatary (2023) review in Assam on aquatic insects diversity, North-East India were found, it was discovered from the entire study that insects from the orders Odonata, Hemiptera, and Coleoptera were most prevalent, followed by those from the orders Diptera and Ephemeroptera. The studied locations are discovered to have the least numberof insects from the Orders Plecoptera, Trichoptera, Hymenoptera, and Collembola.

The variety of aquatic insects from Punjab, India, was examined by Rupinder et. al. (2023) in connection to the physicochemical characteristics of a few selected water bodies. sustainability, preservation, and ecology. An investigation of the diversity of aquatic insects in two ponds in Punjab, India, led to the identification of 11 genera of 5 order.The heterogeneityof pond I was higher in the summer than pond II. A total of 430 aquatic insects from 5 orders were discovered in two ponds.

G., S., Balakrishna, et. al. (2024) an investigation on the aquatic invertebrate fauna's biodiversity in the nizamsagr irrigation reservoir, located in the Kamareddy district of Telangana, India. three phyla comprise the 27 invertebrate species that were discovered in Uttar Pradesh. The phylum Arthropoda was dominated by Mollusca and Annelida species.

Manpreet, Singh, et. al. (2024) survey on caddisfly (trichoptera) were found trichoptera provide diverse ecosystem services in aquatic environments. Climate change affects trichoptera diversity and habitats significantly.

S.B., Sujitha.,. et. al. (2024) survey on heterogeneityand abundance of mayflies (insecta: ephemeroptera) in the Achenkovil river, southern Western Ghats, Kerala, Indiawere found 4,374 mayflies collected, 36 species identified, 9 families categorized. Leptophlebiidae dominant with 13 species, higher diversity in upstream.

Shampa, Sarkar. et. al. (2024) survey on a recent study on various arthropod pests from aquatic plant farms of West Bengal, India. were found aquatic plant farms in west bengal face damage from arthropod pests. common pests include leaf cutter moth larvae, thrips, and spider mite.

A review of the richness and the dispersal of aquatic insects in Qatar's various water bodieswas provided by Fatima Alkhayat et al. in 2024.Brazilian journal of biology a survey conducted between 2015 and 2017 on the heterogeneityof aquatic insects in qatar revealed that there were 6 orders, 12 families, and that dipterans were the most prevalent group, especially in streams.

3. Conclusion

Biodiversity is essential to the processes that support all life on Earth, including humans. The loss of insect diversity and abundance is a reality in the Anthropocene. If we don't stop the decline of our insects this will have serious consequences for humans and all life on Earth. Most aquatic insects are sensitive to pollution and human-caused stress.They have abundant and diverse habits and habitats, and are extremely sensitive to changing environmental conditions. Without insects to help break down and dispose of waste, dead animals and plants would accumulate in our environment, resulting in a poor condition. Insects are underestimated because of their importance in the food chain. Many amphibians, reptiles, birds and mammals depend entirely on them for nutrition.

Compliance with ethical standards

No conflict of interest to be disclosed.

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