Assessing the health of freshwater ecosystems: the role of biomonitoring scores and diversity indices in evaluating aquatic insect populations

Joydeep Das[1*] and Joydev Maity[1]
[1] Department of Fishery Sciences, Vidyasagar University, Midnapore, West Bengal, India
Correspondence Author: Joydeep Das
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Abstract
Aquatic insects play a significant role in freshwater systems as they provide information regarding the ecological conditions and changes that take place by acting as bio monitors, hence conditions such as the presence of mayflies, dragonflies, and stoneflies would serve as an indicator to assess the quality of water. The changes to water bodies such as changes in pH, temperature and oxygen levels lead to shifts in aquatic communities and changes to environmental conditions are closely related which can affect the community makeup. An attempt has been made to highlight the significance of biomonitoring score and diversity index to study freshwater insect.

Keywords: Aquatic insect, Biomonitoring score, Diversity index, Water quality

Introduction

It is necessary to monitor freshwater ecosystems to make sure that the quality of water is suitable and that aquatic ecosystems are healthy. Aquatic insects are often used as bio indicators due to their high sensitivity to environmental perturbations. A number of biomonitoring scores and diversity indices have been developed in relation to aquatic insect communities with an aim of determining the health status of freshwater ecosystems. This review confirmed the previous results from the early studies on the introduction of biomonitoring instruments, their development and efficacy. Equal treatment of sampling strategies with defined metrics like EPT index and Biological Monitoring Working Party (BMWP) score makes sure that aquatic insects can be adequately used in biological monitoring.

Indicators of insect families abundance assess the state of freshwater systems so based on that it can be determinate the state of aquatic ecosystem. Monitoring freshwater habitats requires aquatic insects because they provide sensitive, inexpensive, and detailed assessment tools. They are essential bio monitors for freshwater ecosystems. Their utilization contributes to the preservation and sustainable management of freshwater resources by improving our capacity to recognize and react to ecological shifts. Water bugs are voracious eaters of dipteran larvae. The development of aquatic insect communities may be significantly impacted by the predatory behaviours of these insects as well as those of their vertebrate and invertebrate predators. The four fundamental needs for an animal's existence and sustainability feeding, defense, abiotic adaptation, and reproduction—are also impacted by predator-prey relationships. Native to Australia, the Philippines, and India, *Diplonychus rusticus* is a bug generally referred to as a water bug. It feeds on aquatic insects, especially mosquito larvae, and inhabits shallow waters (Das & Maity, 2023) [15]. According to Das & Maity (2025) [16], they discussed about the spinning secrets of Dineutus sp in Kangsabati River, West Bengal, India.

Characteristics of aquatic insects in Biomonitoring

a) **Diverse life histories:** Diverse life histories, including different feeding techniques, mating habits, and environmental preferences, are exhibited by aquatic insects. Because of their diversity, they can occupy many ecological niches and react to environmental changes in diverse ways.
b) **Accessibility and abundance:** Aquatic insects are useful for routine monitoring since they are rather simple to gather and identify. The majority of freshwater systems have an abundance of them, which gives statistical analysis a large enough sample size.
c) **Sensitivity to pollutants:** The tolerance of different aquatic insect species to pollution varies. While many chironomid larvae (Diptera) can live in deteriorated settings, other fly species are more sensitive to pollution than others. Examples of these species are mayflies (Ephemeroptera) and stoneflies (Plecoptera). This differential sensitivity makes it easier to identify certain types and sources of pollutants.
d) **Presence across trophic levels:** Different trophic levels are occupied by aquatic insects in freshwater environments. They can be detritivores, secondary consumers (predators), or main consumers (herbivores). Their interactions throughout the food web offer a comprehensive picture of the health of the environment.

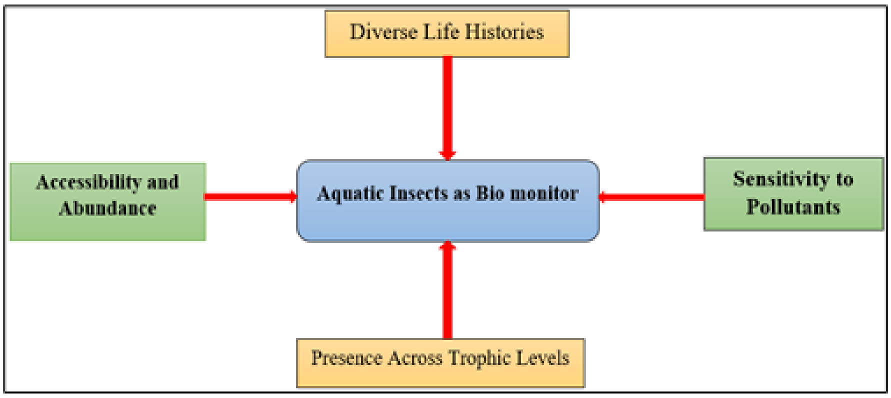


Fig 1: Diagrammatic representation of characteristics of aquatic insect as bio monitor

Monitoring of water quality

Because human demands on water supplies conflict with the needs of freshwater biota, the field of studying macroinvertebrate fauna, including aquatic insects, to assess the ecological health of rivers is one that is rapidly growing worldwide. Conventional chemical methods of monitoring water quality are not particularly good at revealing the effects of pollution on aquatic life. Pollution has an immediate effect on the species that inhabit the impacted region. As a result, bio-indication is a crucial metric for water quality monitoring in aquatic systems. The harmful substances for which a routine chemical analysis may be performed are limited, and the cost of hiring professional people and purchasing the necessary chemical reagents to analyse water samples is rising.

Importance of biomonitoring scores

By measuring the diversity and abundance of aquatic insect taxa, biomonitoring scores aim to assess the ecological well-being of aquatic environments. Developed in the UK during the 1970s, the Biological Monitoring Working Party (BMWP) score is one of the oldest and most used systems. Higher scores indicate a healthier ecosystem. The BMWP score is a numerical value that is assigned to different taxa depending on their sensitivity to pollution (Armitage *et al*., 1983). Later, other regional variants of the BMWP score were created to take into consideration the flora and surroundings unique to each area. Notable modifications that address particular regional biological factors are the South African Scoring System (SASS) and the Australian River Assessment System (AusRivAS) (Dallas, 2004; Wright *et al*., 2000) [11, 34]. These technologies have played a key role in bringing biomonitoring procedures beyond regional boundaries. Aquatic entomofauna play a crucial role as bioindicators for assessing water quality in freshwater ecosystems. This review by Das and Maity (2021) [14] provides a comprehensive analysis of the use of aquatic insects in biomonitoring programs, highlighting their sensitivity to environmental changes and pollution levels. The study discusses various bioassessment indices, such as the Biological Monitoring Working Party (BMWP) and the Ephemeroptera, Plecoptera, and Trichoptera (EPT) index, which are widely applied to evaluate ecological health. It emphasizes the significance of species richness, diversity indices, and functional traits of aquatic insects in reflecting anthropogenic impacts and habitat degradation. The review also outlines the advantages of using entomofauna over traditional physicochemical methods, citing their cost-effectiveness and ability to detect long-term changes. Additionally, the study identifies gaps in research and calls for more region-specific investigations to improve biomonitoring frameworks. This research serves as a valuable resource for researchers and policymakers in water quality management.

Characteristics of aquatic insects as bioindicators

1. **Trophic levels and food web dynamics:** Aquatic insects are found in all trophic levels, ranging from top predators to primary consumers (herbivores). Population fluctuations may be a sign of disturbances to the aquatic food chain, which are frequently brought on by pollution or habitat modification.
2. **Sensitivity to environmental stressors:** The degree to which various species can withstand pollutants like pesticides, heavy metals, and organic waste varies. In contaminated streams, resistant species like some chironomids may multiply while sensitive species like mayflies and stoneflies typically decline.
3. **Life cycle and habitat specificity:** Because aquatic insects have diverse life cycles and ecological requirements, they are reliable indicators of specific environmental conditions. Larval stages are particularly informative because they spend a lot of time in the aquatic environment and accrue the impacts of water quality over time.

Bio-indication by aquatic insect

The field of applied ecology known as "bio-indication" or "bio-monitoring" uses organisms (also known as "bio-indicators") that are found in natural ecosystems to track any alterations or disturbances to the environment. The information gathered is then utilized to manage these ecological systems. A species or group of species that readily reflects the abiotic or biotic status of an environment and depicts the influence of environmental change on a particular habitat, community, or ecosystem is referred to as a bioindicator, also known as an indicator taxon. Stated differently, biological creatures present in the environment can be used to quantitatively assess the health of the ecosystem. A suitable candidate for use in the biomonitoring process is a taxon that reacts to any disturbance in the environment or changes in the environmental conditions. Aquatic ecosystem health is gauged by the existence, absence, and/or trend of macro-invertebrate species in a given area inside a body of water. A variety of organismal groupings, including fish, plankton, algae, and macro-invertebrates, are frequently employed as bioindicators to assess the health of aquatic ecosystems. As biological markers, aquatic insects have proven useful in assessing the environmental parameters of stream ecology. There are several benefits to using aquatic insects for biological monitoring. Because they are sedentary or have restricted movement, aquatic insects can be useful in determining the effects of pollution on a particular ecosystem. Because different aquatic insects can coexist in close proximity and inhabit distinct microhabitats, there are numerous species of aquatic insects that differ in terms of their sensitivity to environmental changes. Moreover, biological approaches that use aquatic insects as bioindicators are less costly, time-consuming, and environmentally benign. Since there are typically no ethical restrictions on insect sampling, aquatic insects are a good subject for study due to their abundance and short life periods. The study by Das and Maity (2019) [12] investigates the seasonal-variation of aquatic Hemiptera and Odonata diversity in the Kangsabati River, West Bengal, India. Sampling was conducted across three seasons—pre-monsoon, monsoon, and post-monsoon to assess species composition and diversity. The study utilized standard diversity indices such as Shannon-Weaver and Simpson's indices to analyze variation across seasons. Results indicated that species-richness and abundance were highest during the monsoon season, attributed to increased water availability and habitat complexity. Pre-monsoon periods showed reduced diversity due to lower water levels and higher-temperatures. The study highlights the influence of seasonal-hydrological-changes on insect-diversity and emphasizes the importance of aquatic insects as bioindicators of ecosystem health. The findings provide valuable insights for conservation efforts and freshwater-biodiversity management in the region.

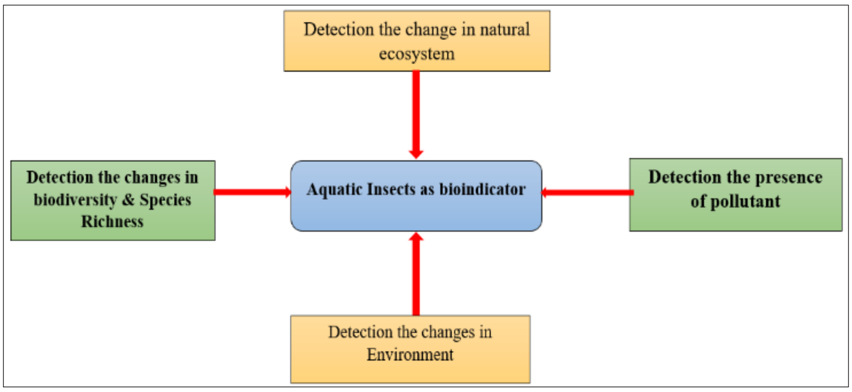


Fig 2: Diagrammatic representation of characteristics of aquatic insect as bio monitor

Pollution assessment skill

Pesticides, heavy metals, organic waste, and other contaminants all have a strong effect on aquatic insects. The effectiveness of biomonitoring scores in determining pollution levels has been shown in numerous research. For instance, the BMWP score was used in a study in the River Thames to identify temporal and spatial fluctuations in the quality of the water, and the results showed a strong link between score variations and pollution levels (Walley & Hawkes, 1996) [33].

Analysing the effects of industrial discharge on aquatic communities has also shown success with the use of diversity indices. Using the Shannon-Wiener Index, a research conducted in the Huangpu River, China, assessed the effects of chemical pollutants and discovered a significant loss in diversity downstream of industrial regions (Cai *et al*., 2017) [6].

The orders Ephemeroptera (mayflies), Odonata (dragonflies, damseflies), Plecoptera (stoneflies), Blattodea (cockroaches), Trichoptera (caddisflies), Hemiptera (water bugs), Megaloptera (alderflies, fish flies, dobsonflies), Neuroptera (spongillaflies, owlies), Coleoptera (beetles), Lepidoptera (moths), Hymenoptera (wasp), some Diptera (midges), and semi Aquatic Orthoptera make up the vast majority of aquatic insects. The assemblages of aquatic insects comprise species that span a wide range of tropical levels and pollution tolerances, making them valuable resources for deciphering cumulative effects. Of all the insect orders, Ephemeroptera, Plecoptera, and Trichoptera (EPT) are excellent markers of the river's environmental conditions. Remarkably, the relative abundance of (EPT) species has been utilized to infer pollution levels because of differences in their susceptibility to organic pollutants. The EPT group of these insects includes families that are completely or nearly exclusively restricted to flowing water, and they reach their maximal growth in streams. Based on their diversity, abundance, and distribution in relation to the physical and chemical characteristics of the habitats, biological indicators are conceptualized using EPT. Even Nevertheless, the employment of aquatic insects for bio-indication appears to be less common in the Asian region, despite the fact that this method offers a less expensive way to monitor the health of aquatic ecosystems without requiring sophisticated equipment. The challenges include a lack of awareness of Malaysia's macroinvertebrate fauna and a lack of understanding and support from the government. For river pollution research, the Malaysian department of Environment's (DOE) current policy does not contemplate the use of aquatic insects as bioindicators of pollution. For the aim of monitoring water quality, the DOE primarily employs the Water Quality Index (WQI), which is based on physico-chemical water characteristics. It is envisaged that the application of aquatic insects, particularly the EPT, as potential bio-indicators can be widely used in biomonitoring of aquatic ecosystem health and can benefit Malaysians in the future with more formal training opportunities and refined analyses, particularly on species identification. The study by Das and Maity (2020) [13] investigates the aquatic-entomofauna of the Kangsabati River near Midnapore town, assessing species-diversity and distribution in relation to environmental factors. A total of 24 aquatic insect species were recorded, belonging to 6 orders and 16 families. The study highlights the dominance of Hemiptera and Coleoptera, indicating moderate water quality conditions. Diversity indices, including Shannon-Weaver and Simpson's indices, were employed to evaluate species-richness and evenness across different sampling-sites. Seasonal variations significantly influenced insect diversity, with higher-abundance observed during the post-monsoon period. Physicochemical parameters such as dissolved-oxygen, pH, and temperature played a crucial role in shaping community-structure. The study underscores the importance of aquatic insects as bioindicators for monitoring freshwater ecosystem-health. Findings suggest the need for regular biomonitoring to assess anthropogenic impacts and ensure sustainable river management.

Habitat alteration of aquatic insect

Freshwater environments are greatly impacted by changes in land use, such as urbanization and agricultural practices. To identify these impacts, diversity indices and biomonitoring scores are essential. The combination of BMWP scores and the Simpson's Diversity Index demonstrated the negative impacts of urban runoff on aquatic insect communities in a research conducted on the Chattahoochee River, USA (Roy *et al*., 2003) [29]. Furthermore, these instruments can be used to track the rehabilitation of damaged environments. Increased BMWP scores and higher Shannon-Wiener Index values, as evidenced by a study conducted in the Kissimmee River, Florida, showed improvements in water quality and insect diversity after habitat restoration (Toth *et al*., 1998) [32].

Conservation and management of aquatic insect

Policies and strategies for conservation and management must also be informed by biomonitoring scores and diversity indexes. They offer a foundation for defining restoration objectives, creating baseline conditions, and assessing the success of management actions. The BMWP score and other biological indices are essential parts of the evaluation framework of the European Water Framework Directive (WFD) that is used to attain "good ecological status" of water bodies (European Commission, 2000) [19]. The significance of biological monitoring in accomplishing sustainable water management objectives is emphasized by this directive**.**

Importance of diversity indices

Aquatic ecosystem health is often assessed using diversity indices in addition to biomonitoring ratings. The two most commonly used metrics are the Simpson's Diversity Index and the Shannon-Wiener Index. By measuring species richness and evenness, these indices paint a complete picture of the composition of communities (Magurran, 1988) [24].

Shannon-wiener diversity index

This index is a valuable-tool for quantifying; and comparing species-diversity, in ecological communities. It considers both the number-of species; and their relative-abundances; making it a more-comprehensive-measure of diversity than simply counting species. The Shannon-Wiener-index of diversity was used for; the analysis of species diversity. The Shannon-Wiener-diversity index helps with the relative-abundance of species. This index provides an overview of species diversity and helps in determining relative-abundance. While, dominant species, largely determine the energy flow of a community, species-diversity, is determined by total species-number; especially those of lesser importance or rarity. Species diversity decreases in systems with strong physico-chemical limiting forces; but species- diversity increases in biologically regulated communities and is related to system stability. Shannon's index of general diversity can be applied to determine community-diversity.

$$H' = -\sum[(pi) * \log(pi)]$$

Where:

H ' = Shannon-diversity index.

pi = Proportion-of-individuals of the (i^{th} species), in the whole community; pi = (n / N).

Where: n= Individuals of the given type; species.

N = Total-Individuals-number. (In the-community)

Higher-values indicate greater-diversity, while lower-values, suggest lower-diversity or dominance by a few species.

Shannon-wiener equitability index

This is a measure-of the evenness-of species-distribution in a-community. It is commonly used in ecology to assess the diversity and also distribution of different-species within a given ecosystem. In ecological-studies use to compare and contrast, the evenness-of species-distributions among different eco-systems; or to track changes in evenness within the same ecosystem over-time. It provides valuable insights into the overall structure and stability of ecological-communities.

$$E = H' / \ln(S)$$

The Equitability-Index-ranges from (0 to 1), with 0 indicating; low-evenness; (dominance of a few species) and 1 indicating high-evenness (equal abundance of all-species). A value closer to 1 suggests a more balanced distribution of individuals, among different-species in the community.

Simpson index

Simpson's Diversity-Index is often preferred to emphasize the influence of dominant-species on overall diversity. It is complementary to other diversity indices; like the Shannon-Wiener-index (Shannon-entropy), which also considers, species evenness. Researchers, use these indices to compare and analyze ecological-communities; track changes in diversity over time; and; assess the-impact of factors like habitat-disturbance or species introductions on community-structure. This index is particularly useful to emphasize the influence of dominant-species on overall diversity. It can be employed to compare-the diversity of different-communities, track changes in diversity over time; and assess-the impact of various ecological-factors on community-structure. The Simpson Index, is one of the-most accurate and reliable indicators of diversity available. It captures variation in species-abundance and distribution. The Simpson-Diversity-Index is a set of diversity indicators that consider, both, richness; and evenness.

Simpson's index (D)

D = n(n-1)/N(N-1)

N= Total number of organisms (of all species).
n= Total-number of-organisms (of a certain species).
The higher the value for this index; the higher the-diversity of species.

Simpson's index of-diversity = 1-D

Simpson's Reciprocal-Index is used in ecological-studies to assess and also compare; the diversity of different-communities. It provides an alternative-perspective to Simpson's Index of-Diversity and can be particularly useful, when, researchers want to emphasize the evenness-of species-distribution within a community.

Simpson's Reciprocal-Index = 1/D

It is important to note that while both the Shannon-Wiener-Diversity Index and Simpson's-Reciprocal Index, provide measures of diversity, they emphasize different aspects.
The Shannon-Wiener-Index considers, both, species-richness and evenness; while Simpson's Index focuses more on dominance and is sensitive to the presence of a few highly abundant-species. Researchers may choose between these indices based-on the specific-aspects of diversity. They want to emphasize in their ecological-studies.
Simpson's Reciprocal-Index ranges from (0 to 1); with 0; indicating high diversity (even distribution-of individuals among-species) and 1 indicating low diversity (dominance of one; or a few species).

Margalef's diversity index

It is useful for comparing; the diversity-of different-communities or eco-systems and can provide insights into the overall biodiversity of a particular area. However, it does not-take into-account; the evenness of species-abundances; or the distribution-of individuals; among species; focusing solely on species-richness. Researchers, often use Margalef's index in conjunction-with other; diversity-indices to gain a more comprehensive understanding of community-diversity and structure.
There are several simple indices of species-richness that divide richness, S, by the number of-species reported, N, by the total-number of individuals in the-sample to try to correct for sampling effects. Margalef's index is one of the-most-famous of these. The total-number of species for a given number-of individuals is measured by this index, which is weighted to species richness.

R = (S-1)/ ln N

Where,
R = Species Richness
S = Total Species-Number (In the community)
N = Total-Individuals-Number (In the community)
Higher-values of Margalef's D indicate greater species richness relative to the total-number of-individuals. Lower values of Margalef's D indicate lower-species richness relative to the total-number of-individuals.

Pielou's evenness index

It also known-as; the Pielou's J index; or simply the Evenness Index, is a mathematical formula, used in ecology to measure, the evenness; or equitability of species-abundance within a community. It is often, used alongside other diversity indices; like the Shannon-Wiener-index to provide a more-comprehensive picture of the diversity and structure of ecological-communities.
Pielou's evenness index is useful for comparing; the evenness-of species in different ecological-communities; or assessing changes in evenness over time in response to ecological-disturbances or management efforts. It provides insights into the balance of species-abundances within a community; which can be important for understanding community structure and ecosystem stability.

J ˈ = H / H ˈ max

Where:
J ˈ = Pielou equality index
H ˈ = Shannon diversity index value. H ˈ max = ln (S)
S = Number-of species.
Pielou's evenness-index (J) ranges from (0 to 1) with the following interpretations; J = 0: Indicates maximum inequality; or minimum evenness. One species dominates the community completely. *J*=1: Indicates perfect evenness. All species in the community have equal abundance; and there is no dominance. Values of J between 0 and 1, indicate varying degrees of evenness; with higher-values indicating a more even distribution of species-abundances.

Menhinick's diversity-index

It is used to assess and compare; the diversity-of different ecological-communities; particularly, when they want to account for variations in sample size. It can be especially valuable in ecological research, when comparing sites with different sampling effort or when investigating, the effects of disturbances; or environmental factors on species richness.

D=S/√ N D= Menhinick-Diversity-Index

S= Number-of different-species.

N=Total-number (individuals).

Higher-values of Menhinick's (D) indicate greater species-diversity, relative to sample size. Lower-values of Menhinick's (D) **i**ndicate lower species-diversity, relative to sample size. It's important to note that, Menhinick's Diversity-Index is a relatively simple and intuitive metric, that can be useful for comparing; the diversity of different sites; or communities; especially, when you have varying sample sizes.

Stream-Invertebrate-Grade-Number (SIGNAL)

Stream-Invertebrate-Grade Number, also known-as, the Invertebrate Community Grade Number; or simply the Grade Number, is a numerical rating, used in freshwater-ecology and stream assessment to characterize the quality and ecological-health of a stream; or river based-on, the composition and diversity of invertebrate species found in the water. Stream-Invertebrate-Grade Number-Average-Level: It's a straight forward system for evaluating macro-invertebrate ('water beetle') samples. The SIGNAL score indicates the quality of the water in-the river (from which, the sample, was taken). Low salinity, turbidity; and nutrients (such as nitrogen and phosphorus) are likely to be found in rivers; with high SIGNAL-scores. They are also likely to have a lot of-dissolved-oxygen (DO). SIGNAL can provide indications of the types of pollution and other physical and chemical elements; that affect macro-invertebrate communities, when-used in conjunction-with macro-invertebrate richness. All macro-invertebrates had to be identified; to the-taxonomic (classification) family-level in the initial-version of SIGNAL. Most agency biologists, use this level regularly. Species-level identification is a specialized and time-consuming task, when providing more information, especially on conservation values. Many community groups, such as those involved in the national water-watch-program, are unable to identify individuals down to the family-level. Depending on the type of macro-invertebrate, these groups are usually identified at the taxonomic-levels of order, class; and phylum.

Signal-2 Score = (Total Mark × Weighting Factor) / (Total Weighting Factor)

SIGNAL-2: (0 to 7: Indicates water-pollution); (Greater than 7: Suggests clean water and good habitat).

Berger-Parker-Dominance-Index is a quick and simple tool, for assessing the structure of a community and also identifying the most dominant species. However, it does not-provide information, about the overall diversity or evenness of the community; which may require the use of other diversity indices, such as; the Shannon-Wiener-Index or Simpson's Diversity Index. Index of Berger-Parker is used to identify the dominant status of aquatic entomofauna.

d = Nmax / N

Nmax = Individual Number (Most-abundant-species).

N = Individual Number (Total No.).

The index-ranges from (0 to 1), with higher values; indicating a greater dominance of a single-species. When, *d* is equal-to 1, it means that a single species completely, dominates the community, while a value of 0 indicates, that all species, are equally-abundant.

Biological-Monitoring-Working-Party (BMWP) method is valuable for monitoring and managing freshwater ecosystems; as it provides a relatively rapid and cost-effective; way to assess water-quality and detect changes in ecological-health over time. It's often, used in environmental impact assessments; conservation efforts; and water-quality monitoring programs.

Average-Score-Per-Taxon (ASPT) is a valuable-tool for monitoring and managing freshwater-ecosystems; as it provides a quantifiable-measure of ecological-health and water-quality. Different regions and organizations, may use variations of the ASPT-method with scoring-systems tailored to the specific macro-invertebrate taxa and environmental conditions of their study area.

BMWP and ASPT are ecological indices, used to assess the water-quality of streams and rivers, based-on, the types of macro-invertebrates (aquatic insects, crustaceans; and other organisms without a back-bone) found in these aquatic ecosystems. Indices are widely, used in freshwater biomonitoring programs to evaluate the health and ecological condition of water bodies.

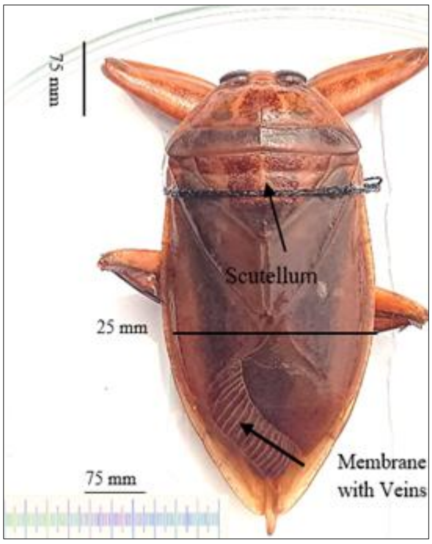
BMWP (Biological-Monitoring-Working-Party scores)

(150 greater than: Indicate that very high-water quality), (101 to150: Indicate that high water quality), (51 to 100: Indicate that Good water quality), (17 to 50: Indicate that water-quality moderate), (0 to16: Indicate that water-quality poor). ASPT (Average Score-per-Taxon scores): (Less than 4: Indicate that probable severe water pollution), (4 to 5: Indicate that probable moderate water pollution), (5 to 6: Indicate that doubtful water quality), (Greater than 6: Indicate clean water quality).

Engelmann scale

The Engelmann-scale is a tool for determining the dominance-status of different-species in population or sample. Relative abundance <1% = Subrecedent, (1.1- 3.1) =Recedent, (3.2-10%) =subdominant, (10.1-31.6%) =Dominant, >31.7% =Eudominant.

Biomonitoring ratings and diversity indexes are widely used, however they have certain drawbacks. The diversity of taxonomic knowledge needed for precise identification of aquatic insects is a significant obstacle that may have an impact on the consistency of findings (Bailey *et al*., 2001) [2]. Furthermore, seasonal fluctuations and hydrological conditions are examples of environmental factors that might affect insect groups, making it more difficult to interpret data from biomonitoring (Bonada *et al*., 2006) [4]. Furthermore, these instruments' sensitivity to minute alterations in the surroundings might occasionally produce unclear outcomes. For example, although a high degree of diversity is usually a sign of excellent quality water, some forms of moderate pollution can actually increase diversity by providing niches for opportunistic species, which might possibly confuse analyses (Cairns & Pratt, 1993) [7]. Technological developments in molecular methods, including DNA barcoding and metabarcoding, present encouraging paths for improving biomonitoring procedures. These techniques can lessen the dependency on taxonomic expertise by increasing the efficiency and accuracy of species identification (Hajibabaei *et al*., 2011) [21]. Furthermore, combining remote sensing data, diversity indices, and biomonitoring scores with predictive modelling can offer a more thorough understanding of freshwater ecosystems (Friberg *et al*., 2011) [20]. The creation of region-specific indexes that take into consideration local ecological and environmental circumstances is another avenue for future research. Tailoring biomonitoring instruments to particular areas can improve their applicability and efficiency in a variety of geographic settings (Rosenberg & Resh, 1993) [28].



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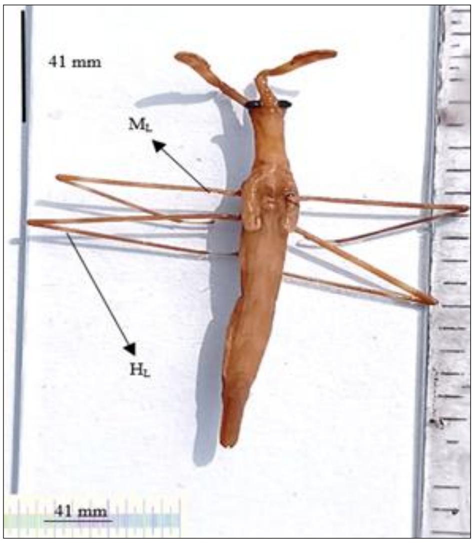

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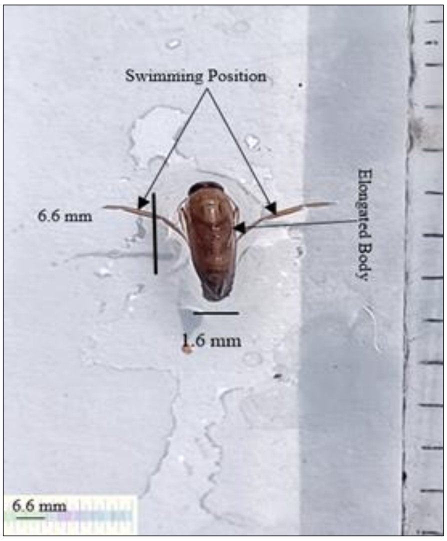

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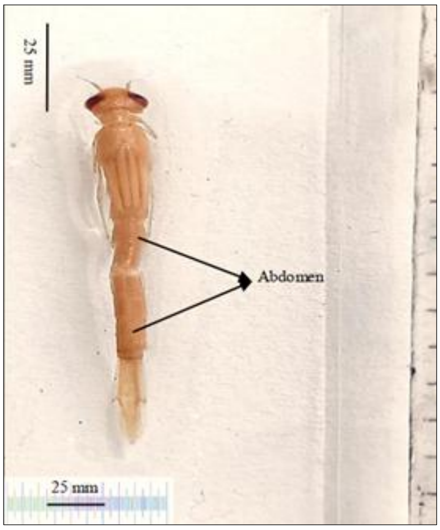

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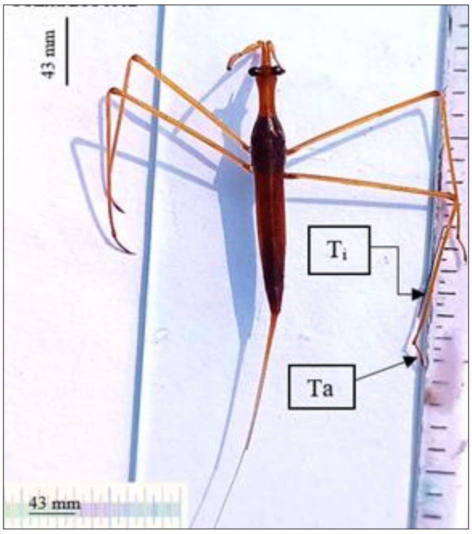

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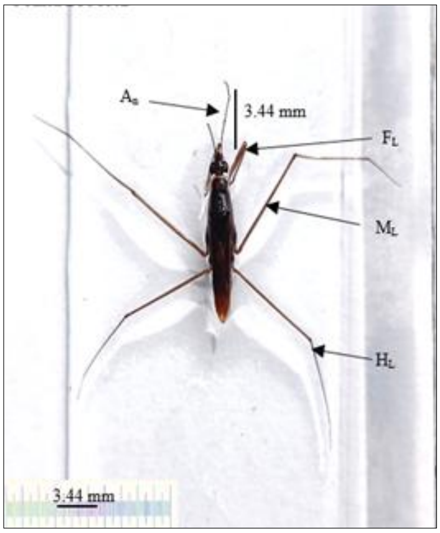

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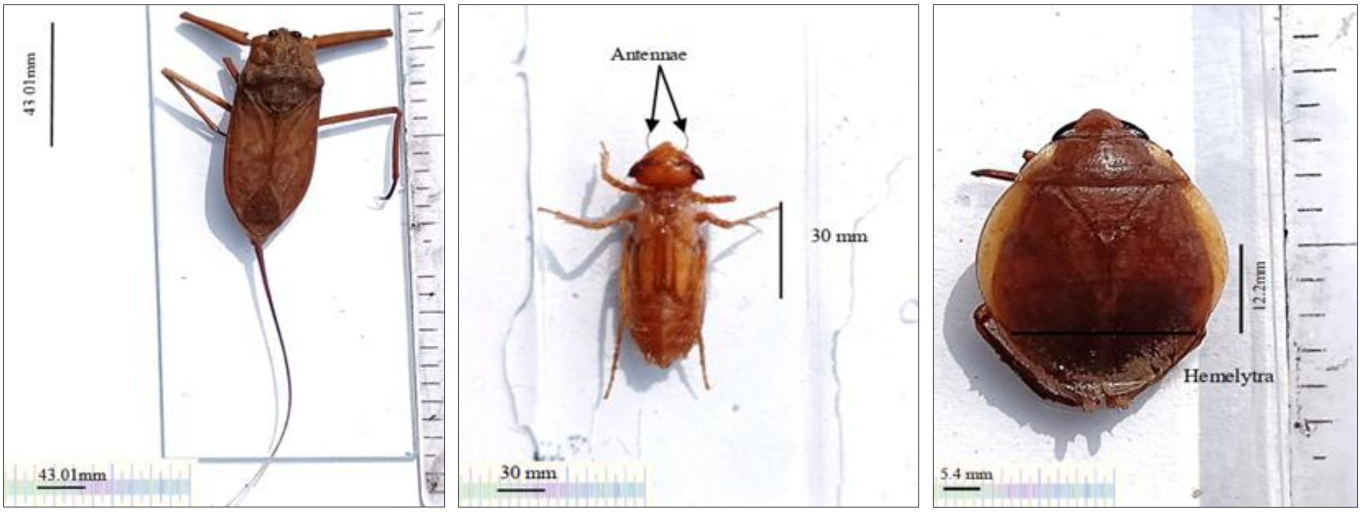

(7) (8) (9)

Fig: (1) Body Length: 75 mm, M, *Lethocerus indicus,* Elliptical narrow body, Adult **(2)** *Cercotmetus pilipes* (Nepidae) Adult, Body length:41mm **(3)** *Anisops breddini* (Notonectidae), body length:6.6 mm. Body width:1.6mm **(4)** *Ischnura sp* (Coenagrionidae), Larvae. Dorsal View, Body Length:25 mm. **(5)** Length of body:43mm, *Ranatra sp* (Nepidae), Adult.Ti-Tibia, Ta-Tarsus, Dorsal. **(6)** *Gerris sp* (Gerridae), Antenna length:3.44mm Adult, F_L-Fore Leg, M_L-Mid Leg, H_L-Hind Leg. **(7)** *Laccotrephes sp* (Nepidae), Body length:43.01mm. **(8)** Anax sp., (Aeshnidae), Larvae, Dorsal View, Body Length:30 mm.
(9) Length of Hemelytra 12.2mm, width:5.4mm, *Diplonychus sp.*

Table 1: Interpretation for different Index

Index	Interpretation
Shannon -Wiener Diversity Index(H')	Higher values indicate greater diversity, while lower values, suggest lower diversity or dominance by a few species.
Shannon-Wiener Equitability Index (E_H)	The Equitability Index ranges from (0 to 1), with 0 indicating; low evenness; (dominance of a few species) and 1 indicating high evenness (equal abundance of all species). A value closer to 1 suggests a more balanced distribution of individuals, among different-species in the community.
Simpson's Diversity-Index (D)	The higher the value for this index; the higher the diversity of species.
Simpson's Reciprocal-Index (1/D)	0 indicating high diversity (even distribution of individuals among-species) and 1 indicating low diversity (dominance of one; or a few species).
Margalef's Index (D_{Mg})	Higher-values of Margalef's D indicate greater species richness relative to the total-number of-individuals. Lower values of Margalef's D indicate lower-species richness relative to the total-number of individuals.
Pielou's evenness index (J)	Pielou's evenness-index (J) ranges from (0 to 1) with the following interpretations; J = 0: Indicates maximum inequality; or minimum evenness. One species dominates the community completely. J=1: Indicates perfect evenness. All-species in the-community have equal-abundance; and there is no dominance. Values of J between 0 and 1, indicate varying degrees of evenness; with higher-values indicating a more even distribution of species-abundances.
Menhinick's Diversity-Index (D_{Mn})	Higher-values of Menhinick's indicate greater species-diversity, relative to sample size. Lower-values of Menhinick's (D) indicate lower species-diversity, relative to sample size.
Berger Parker Dominance-Index (d)	The index-ranges from (0 to 1), with higher values; indicating a greater dominance of a single-species. When, d is equal-to 1, it means that a single species completely, dominates the community, while a value of 0 indicates, that all species, are equally-abundant.
Engelmann Scale	Relative abundance <1% = Subrecedent, (1.1- 3.1) =Recedent, (3.2-10%) =subdominant, (10.1-31.6%) =Dominant, >31.7% =Eudominant.

Table 2: Interpretation values for SIGNAL, SIGNAL-2

SIGNAL Score (Chessman, B. 1995)	Interpretation of water quality
>6	Clean Water
5-6	Mild Pollution
4-5	Moderate Pollution
<4	Severe Pollution
SIGNAL 2 Score (Chessman, B. 2003)	Interpretation of water quality
>7	Clean water and good habitat
0-7	Polluted Water

Table 3: Interpretation values of BMWP and ASPT

BMWP Score (Chesters, R.K. 1980)	Interpretation of water quality
>151	Very high-water quality
101-150	High water quality
51-100	Good water quality
17-50	Water-quality moderate
0-16	Water-quality poor
ASPT Score (Mandaville S.M. 2002)	Interpretation of water quality
>6	Clean water quality
5-6	Doubtful water quality
4-5	Probable water quality
<4	Probable severe water pollution

Conclusion

Using diversity indices and biomonitoring scores is still essential to managing freshwater ecosystems. In order to guarantee the sustainable management and preservation of these key resources, as well as to facilitate prompt and informed environmental decision-making, they must be further developed and refined. Life need water. In order to guarantee a long-term, sufficient supply of high-quality water, river protection is crucial. The building of dams and barrages that alter the management and diversion of river flow is a major hazard to the river biota. Anthropogenic disturbances that have the potential to cause fauna loss have a significant impact on the species richness of river fauna.

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