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Aquatic entomofauna as biological indicator of water quality: A review

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Abstract
Aquatic entomofauna spend all or part of their life cycle in the water bodies. From a logical standpoint, aquatic entomofauna make good study specimens because they are taxonomically rich, diversified, abundant and easily surveyed. Abundance and diversity of aquatic entomofauna gives an alarm or an indication of the overall health of the water body. According to aquatic entomologists, aquatic entomofauna respond to the specific changes in the water conditions and they have become indicators of water body. The presence or absence of some aquatic entomofauna indicates the degree of pollution. Physical and chemical analysis are very expensive compare to biological analysis. Concentration of pollutants vary greatly with time and space. So, physical and chemical monitoring cannot detect the non-point source of pollution. But, seasonal sampling of aquatic entomofauna community provides an indication of past condition as well as present condition of the selected water body. Every aquatic entomofauna has different tolerance value in which only few entomofauna can survive in polluted ecosystems. Thus, condition of water body can be evaluated by using aquatic entomofauna. Throughout the world, aquatic entomofauna is widely recommended by aquatic entomologist as the biological indicator of water quality. Using aquatic entomofauna for routine biomonitoring of aquatic body will facilitate better conservation of environment. The goal of this paper is to summarise aspects of biomonitoring, the use of aquatic entomofauna in predicting the state of aquatic systems and the need for research, with a focus on recent developments of aquatic biodiversity Index and biomonitoring scores.

Keywords: aquatic entomofauna, bioindicator, biomonitoring, water quality

Introduction

Biomonitoring is generally defined as multiple and routine biological assessments over time for the detection of changes in biological condition using suitable sampling and analysis methods. Biological monitoring is simply clarified as "the systematic use of living organisms or their responses to determine the condition or changes of the environment" [27, 10, 20]. Biological indicator is an organism that gives information about the quality of the environment [16, 17, 15]. A 'good indicator' should have the specific characteristics as follows: Numerical abundance, high ability for quantification and standardization, taxonomic soundness, wide distribution, low mobility, well-known ecological characteristics, high sensitivity to environmental stressor, suitability for laboratory experiments **[26,12,9]**. Aquatic entomofauna as bioindicator has been demonstrated by many studies [22, 18]. Aquatic entomofauna have an ability to tolerate highly environmental stress than fish and plankton **[1]**. Aquatic entomofauna serves as a bio-indicator species that gives a more accurate information of the changing water body than chemical data [25]. Aquatic entomofauna provides a response to the pollution through an early warning to possible harm of the water body because aquatic entomofauna spends all or part of their life cycle in a water body that's why entomofauna show the effects of point and nonpoint contaminants, physical habitat alteration over their life cycles [19]. In river ecosystems, there are many different biomonitoring techniques currently applied. The selection of an effective technique depends on the problems being tackled and the resources available. Diversity indices, biotic indices and functional feeding groups (FFGs) are possible bio monitoring methods. Abundance and Relative Abundance were helped to analysis the data for understand the community structure of aquatic Entomofauna. Shannon-Wiener Diversity index gives the idea about species diversity and helps in relative abundance [30]. Simpson's diversity index also helps to understand the abundance of common species present area [31]. Margalef's index points to understand the water quality of the given area [14]. Berger-Parker index helps to point out the dominance status of aquatic Entomofauna depending upon their abundant species present in the sample [2]. Pielou's Evenness index points to understand the degree where the abundances are equal within the species in a sample [24]. Engelmann's Scale helps to determine the dominance status of different species in a sample or in a community [7]. Using Engelmann's scale, order Hemiptera was dominant group in river Kangsabati [6]. Bio monitoring Scores (BMWP, ASPT, SIGNAL 2) helps to understand water quality and biological quality of a water body [11, 13, 4]. The aquatic entomofauna is a valuable bio-indicator that offers a more detailed interpretation than chemical data of the evolving water body or river system. Poor water quality is demonstrated by deteriorating populations of stoneflies (Order-Plecoptera) [23, 28]. Epiphytic algae and small particulate organic matter are eaten by mayfly nymphs (order-Ephemeroptera) and highly sensitive to oxygen depletion, acidification [8]. Dragonfly nymph populations (Order-Odonata) show that other invertebrates and macrophytes are rich. They prefer environments which are freshwater, non-contaminated and well oxygenated [3]. In the biological control of mosquito larvae, some families of bugs (Order-Hemiptera) may be used [21, 29]. The role and importance of aquatic entomofauna in biomonitoring and the need for study are addressed in this paper, highlighting several categories for research fields that appear to be especially important for future studies. The three wide categories are: the value of aquatic entomofauna, the preference of biological monitoring species, and the index built for freshwater monitoring.

Aquatic Entomofauna Play Important Role as Bio indicator

River ecologists have long known that ecosystem health monitors can be excellent for the composition and abundance of aquatic entomofauna. These species' abundance and diversity are good local river health indicators because they have more limited movement than fish and react rapidly to contaminants such as nutrients and sediments and other environmental stress. For the following reasons, aquatic entomofauna are regarded as bioindicators:

- For all or for most of their lives, they live in water.
- They stay in areas that are appropriate for their survival.
- They are easy to handle and easy to collect.
- The tolerance of the quantity and forms of emissions varies.
- With practice, they are easy to recognize in a laboratory and in the field.
- Often, they live for more than one year in the aquatic habitat.
- They've got restricted mobility in their own habitat.
- They are the integrators of the water body conditions.
- They are most important components of food web.

Water Quality and Bio monitoring Scores

A select group of species that used in biological monitoring programmers are aquatic entomofauna. Depending on the lifespan of the aquatic entomofauna within the same system can live for several months to several years. Therefore, aquatic entomofauna live in an aquatic community. The system is sufficiently long to represent chronic pollutant impacts, and yet sufficiently short to respond to relatively acute changes in water quality. Unlike fish, these species appear to be relatively immobile and are constantly exposed to surface components as a result. The water which they inhabit. Thus, due to the restricted mobility of aquatic entomofauna and their relative inability to travel away from adverse environments, comparing the populations of these species will also classify the location of persistent sources of pollution. There is different response to changes in water chemistry, water quality and physical habitat from aquatic entomofauna. The response of each aquatic entomofauna to environmental disturbances results in observable and sometimes predictable changes in the population level in abundance and composition. Sublethal effects, such as mouthpart deformities in chironomid midges (aquatic fly larvae), may also be indicated by aquatic entomofauna. Aquatic entomofauna and chironomids are used as bioindicators of environmental stress, including morphological deformities, in aquatic environments at different levels. In cases of legacy environmental problems, deformities of invertebrates are widely used as ecotoxicological endpoints.

The water quality of a river, also referred to as 'ecological health' or 'river health,' may be measured by the presence or absence of animals living in water. This is called bioassessment and shows how well water can support animal life rather than the amounts of contaminants and microbes associated with human drinking water quality. Biotic indices are used to represent the 'health' of water in numerical terms. The SIGNAL index is an easy-to-use biotic index. SIGNAL is a simple biotic index for macroinvertebrates that uses the degree of pollution tolerance of different macroinvertebrates to create a single biotic index. Site score and water quality ranking of the river, stream or pond being studied. Waters with a high SIGNAL site score are likely to have high salinity, turbidity and nutrient levels of dissolved oxygen (nitrogen, phosphorous). Still waters and slow-flowing lowland waters, by their very nature, will often yield a lower site ranking, since physical habitat and chemical levels are inherently different. Aquatic entomofaunas, which are categorized as very sensitive, occur naturally in still waters or in lowland waters with a slow flow. SIGNAL 2 (Table 1) was created from data obtained from the National River Health Program to create a score system that can be used throughout Australia. BMWP and SIGNAL 2 score (Table 2) indicated that biological and water quality of river Kangsabati were moderate [5].

In tracking quality patterns over time, biomonitoring has proved invaluable. In order to achieve and preserve the highest quality of water and the atmosphere, environmental activists use resident species in lake, river, water and humid waters as responsive bioindicators of transition. The aim of this work is to provide tolerance values for some of the many aquatic insects, which are intended to reflect organic tolerance and the many other forms of contaminants and pollutants. For assessing the extent of environmental contamination, chemical-physical measurements and biological monitoring or biomonitoring are commonly used. The most direct approach to reveal pollution is chemical analysis such as water or sediment. It cannot afford strong proof integrated effects and future toxicity of pollutants on species and habitats. They will, in practice, be investigated by biological monitoring. Biomonitoring is now regarded as one of the most important resources available to environmentalists in the arsenal. It provides an impression of past and current status as a video tape, while chemical-physical analysis represents present conditions when a sample is taken as snapshots [13].

Tables

Table 1: Aquatic Entomofauna Order-Family-SIGNAL 2 grade (Table of Bruce Chessman, 2003)

Order	Family	Signal 2 grade
Odonata	Aeshnidae	4
Odonata	Coenagrionidae	2
Odonata	Cordulephyidae	5
Odonata	Corduliidae	5
Odonata	Diphlebiidae	6
Odonata	Gomphidae	5
Odonata	Hemicorduliidae	5
Odonata	Hypolestidae	9
Odonata	Isostictidae	3
Odonata	Lestidae	1
Odonata	Libellulidae	4
Odonata	Lindeniidae	3
Odonata	Macromiidae	8
Odonata	Megapodagrionidae	5
Odonata	Protoneuridae	4
Odonata	Synlestidae	7
Odonata	Synthemistidae	2
Odonata	Telephlebiidae	9
Odonata	Urothemistidae	1
Hemiptera	Belostomatidae	1
Hemiptera	Corixidae	2
Hemiptera	Gelastocoridae	5
Hemiptera	Gerridae	4
Hemiptera	Hebridae	3
Hemiptera	Hydrometridae	3
Hemiptera	Mesoveliidae	2
Hemiptera	Naucoridae	2
Hemiptera	Nepidae	3
Hemiptera	Notonectidae	1
Hemiptera	Ochteridae	2
Hemiptera	Pleidae	2
Hemiptera	Saldidae	1
Hemiptera	Veliidae	3
Plecoptera	Austroperlidae	10
Plecoptera	Eustheniidae	10
Plecoptera	Gripopterygidae	8
Plecoptera	Notonemouridae	6
Trichoptera	Antipodoeciidae	8
Trichoptera	Atriplectididae	7
Trichoptera	Calamoceratidae	7
Trichoptera	Calocidae	9
Trichoptera	Conoesucidae	7
Trichoptera	Dipseudopsidae	9
Trichoptera	Ecnomidae	4
Trichoptera	Glossosomatidae	9
Trichoptera	Helicophidae	10
Trichoptera	Helicopsychidae	8
Trichoptera	Hydrobiosidae	8
Trichoptera	Hydropsychidae	6
Trichoptera	Hydroptilidae	4
Trichoptera	Kokiriidae	3
Trichoptera	Leptoceridae	6
Trichoptera	Limnephilidae	8
Trichoptera	Odontoceridae	7
Trichoptera	Oeconesidae	8
Trichoptera	Philopotamidae	8
Trichoptera	Philorheithridae	8
Trichoptera	Polycentropodidae	7
Trichoptera	Tasimiidae	8
Coleoptera	Brentidae	3
Coleoptera	Carabidae	3
Coleoptera	Chrysomelidae	2
Coleoptera	Curculionidae	2

Coleoptera	Dytiscidae	2
Coleoptera	Elmidae	7
Coleoptera	Gyrinidae	4
Coleoptera	Haliplidae	2
Coleoptera	Heteroceridae	1
Coleoptera	Hydraenidae	3
Coleoptera	Hydrochidae	4
Coleoptera	Hydrophilidae	2
Coleoptera	Hygrobiidae	1
Coleoptera	Limnichidae	4
Coleoptera	Microsporidae	7
Coleoptera	Noteridae	4
Coleoptera	Psephenidae	6
Coleoptera	Ptiliidae	3
Coleoptera	Ptilodactylidae	10
Ephemeroptera	Ameletopsidae	7
Ephemeroptera	Baetidae	5
Ephemeroptera	Caenidae	4
Ephemeroptera	Coloburiscidae	8
Ephemeroptera	Leptophlebiidae	8
Ephemeroptera	Oniscigastridae	8
Ephemeroptera	Prosopistomatidae	4
Ephemeroptera	Siphlonuridae	10
Ephemeroptera	Teloganodidae	9
Neuroptera	Osmylidae	7
Neuroptera	Sisyridae	3
Megaloptera	Corydalidae	7
Megaloptera	Sialidae	5
Lepidoptera	Pyralidae	3
Diptera	Tanyderidae	6
Diptera	Tanypodinae	4
Diptera	Thaumaleidae	7
Diptera	Tipulidae	5
Diptera	Aphroteniinae	8
Diptera	Athericidae	8
Diptera	Blephariceridae	10
Diptera	Cecidomyidae	1
Diptera	Ceratopogonidae	4
Diptera	Chaoboridae	2
Diptera	Chironominae	3
Diptera	Culicidae	1
Diptera	Diamesinae	6
Diptera	Dixidae	7
Diptera	Dolichopodidae	3
Diptera	Empididae	5
Diptera	Ephydridae	2
Diptera	Muscidae	1
Diptera	Orthocladiinae	4
Diptera	Pelecorhynchidae	10
Diptera	Podonominae	6
Diptera	Psychodidae	3
Diptera	Scatopsidae	1
Diptera	Sciaridae	6
Diptera	Sciomyzidae	2
Diptera	Simuliidae	5
Diptera	Stratiomyidae	2
Diptera	Syrphidae	2
Diptera	Tabanidae	3

Table 2: Data interpretation of Signal 2 Score

Signal 2 Score	Interpretation
0-7	Indicate that water is polluted
>7	Indicate that water is clean

Conclusions

Aquatic entomofauna give an excellent path of exploring the biological aspects of water quality. Scientists are increasingly using standards for water quality dependent on macroinvertebrates in many countries. Bioassessment application in water resource programs collaboration between scientists, resource managers and other individuals interested in the sustainability of systems is required. To resolve the balance between land use and land use, knowledge of ecological status based on true aquatic indicators is important. Cultural uses of ecologically integral water in order to accomplish the goal of environmental conservation and regeneration. The lessons learned from success stories in the European Union (EU) and the USA, as well as in some emerging Asian and African countries, serve as a strong basis for developing the Water Protective Law for their aquatic resources in their infancy. For the ability of every nation to fundamentally control the health of its waters, a solid monitoring and evaluation program is essential. It is important to initiate a systematic biomonitoring program to use biological indicators to achieve that goal. The value of precision in taxonomic identification, the use of modern multivariate techniques and predictive modeling, the urgent need for toxicity testing to resolve ecosystem issues, ecosystem-level extension.

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