academicJournals

Vol. 5(6), pp. 311-316, June, 2013
DOI: 10.5897/IJBC2013.0567
ISSN 2141-243X © 2013 Academic Journals
http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Application of diversity indices to crustacean community of Wular Lake, Kashmir Himalaya

Javaid Ahmad Shah* and Ashok K. Pandit

Aquatic Ecology Laboratory, Centre of Research for Development, University of Kashmir 190006, J&K, India.

Accepted 13 June, 2013

The present work is aimed at comparing the various diversity indices applied to crustacean community assemblages in the Wular Lake during September 2010 to August 2011. In all, 42 taxa were identified, of which 23 were Cladocera, 16 were Copepoda and only 3 were Ostracoda. Different species have different ecological requirements which enable them to thrive well in their ecological niches which determine the patterns and extent of community structure in an ecosystem. Various indices were used to assess the basic community structure of crustacean zooplankton, their species distribution and interactions so as to have an insight into the ecosystem health at large. The study further reveals direct relationship between Shannon-Wiener, Simpson and high evenness indices. However, sensitivity to sample size is an important aspect in majority of the indices.

Key words: Crustacean, comparison, diversity indices, Shannon-Wiener, Simpson.

INTRODUCTION

Species in the natural community behave differently to the varying environmental conditions (Soininen, 2007; Van Dam et al., 1994; Shah et al., 2013; Shah and Pandit, 2013), whether abiotic (Rindi and Batelli, 2005; Charles et al., 2006) or biotic (Coleman, 2002; Underwood and Chapman, 1996), as a consequence diverse niche organizations come into being which consequently result in the evolution of diverse communities. Use of different diversity indices continue to elevate disagreement among the naturalists, whether there exists a biological relationship between them or not (Johnson and Raven, 1970; Auclair and Goff, 1971; Risser and Rice, 1971). Early researchers interpret their results as the number of species per sample or per liter as an index of their diversity. However, such a vague procedure does not help in distinguishing the relative abundance in terms of community structure of the different species besides other characteristics. Diversity indices are important statistical measure used to characterize richness (the number of species) and evenness (how uniform abundant species are in a sample) of the species in the community (Magurran, 1988) and is used as a tool for determining the health and pollution of an ecosystem (Norris and Georges, 1993; Schmitz and Nadel, 1995; Guerold, 2000). Consequently, different indices of diversity were taken into account to highlight their importance with respect to crustacean community.

MATERIALS AND METHODS

Study area

Wular Lake, the largest freshwater lake in Indian subcontinent, is a shallow macrophyte dominated rural valley lake, located 34 km north-west of Srinagar city in the valley of Kashmir between 340 16' -340 20' N latitude and 740 33' – 740 44' E longitude. The lake is mono-basined, elliptical in shape and is of fluviatile origin, formed by the meandering of River Jhelum. It lies at an altitude of 1580 m (a.m.s.l.) and its depth on an average is 3.6 m though reaching 5.8

*Corresponding author. E-mail: javaidshah31@gmail.com.

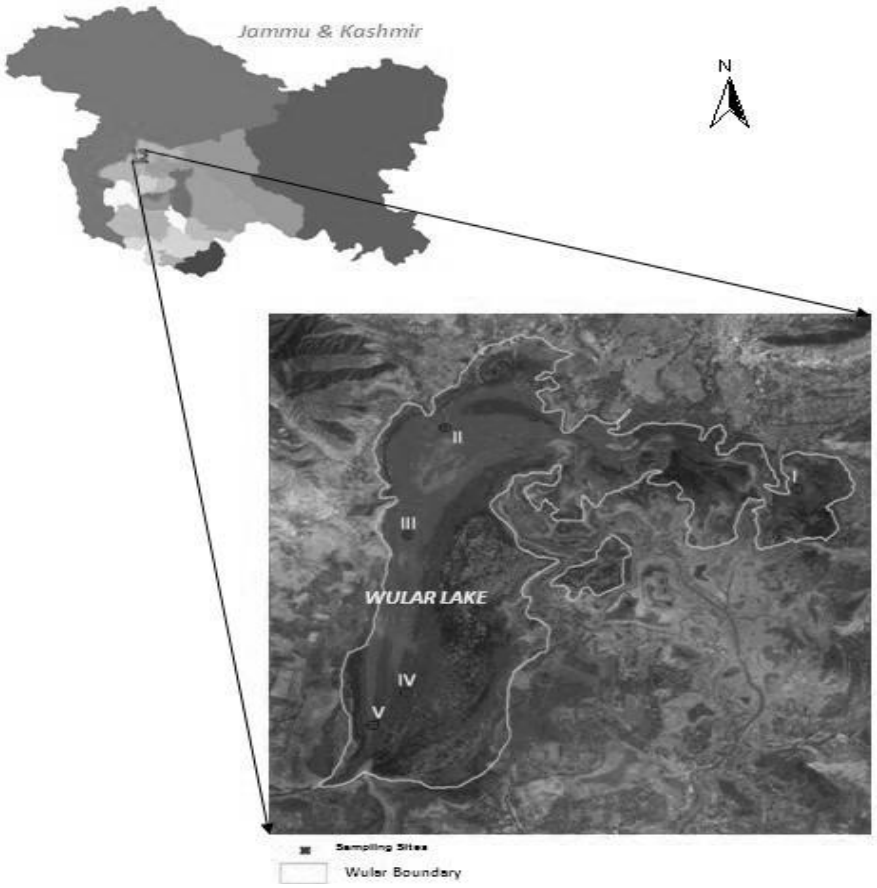

Figure 1. Map of Wular Lake with five sampling sites.

Table 1. Location of five study sites in Wular Lake.

Site	Latitude	Longitude	Distinguishing features
I	34°21´ 51" N	74° 39´42" E	Anthropogenic pressures
II	34°24´ 15" N	74° 32 ´35"E	Good macrophytic growth
III	34° 21´ 29" N	74° 31´ 48" E	Profuse growth of macrophytes
IV	34°17´43" N	74° 31´30" E	Centre of lake basin
V	34° 17´ 16" N	74° 30 ´25" E	Near outlet of the lake

m at its deepest point. The major inflows to the Wular Lake are River Jhelum and streams like Gurror, Madhumati and Erin. The lake plays a significant role in the hydrographic system of Kashmir valley by acting as a huge reservoir and absorbs high annual flood of River Jhelum. The largest freshwater shallow lake in 1990 has assumed the status of Ramsar Site, a Wetland of International Importance. Five study sites differing in various characteristics were chosen for conducting the present study (Figure 1 and Table 1).

For qualitative analysis, crustacean samples were collected on monthly basis at five different study sites. Samples were collected on monthly basis from September 2010 to August 2011 by filtering 100 L of subsurface lake water through Birge conical crustacean net having a mesh size of 75 µm. Preservation of the samples was carried out in 4% formalin. Identification of the crustaceans was done with the help of standard works of Pennak (1978) and Edmondson, (1992). Counting of crustaceans was carried out with the help of Sedgewick Rafter plankton counting chamber and the results are expressed as individual per litre (ind./l.). Results of various diversity indices are depicted on annual mean basis and are calculated by the software Past. Pearson correlation coefficient (SPSS statistical version 11.5 for Windows 7) was used to further authenticate the results.

RESULTS AND DISCUSSION

The three groups of Crustacea comprising Cladocera (23), Copepoda (16) and Ostracoda (3) were recorded during the entire study. Eight diversity indices used were Dominance, Shannon-Wiener index (1949), Simpson (1949), Evenness, Menhinick (1964), Margalef (1968), Fisher_alpha (Fisher et al., 1943) and Berger-Parker (1970) to find out the interrelationship between them

Table 2. Diversity indices* at five study sites of crustaceans from September 2010 to August 2011 in Wular Lake.

	Cladocera	Copepoda	Ostracoda
Site I			
Dominance	0.17	0.18	0.38
Shannon	0.79	0.99	1.04
Simpson	0.22	0.31	0.37
Evenness	0.48	0.58	0.46
Menhinick	0.47	0.40	0.30
Margalef	1.08	0.99	0.44
Fisher_alpha	1.34	1.21	0.58
Berger-Parker	0.23	0.25	0.50
Site II			
Dominance	0.12	0.28	0.17
Shannon	2.19	1.86	1.09
Simpson	0.41	0.47	0.27
Evenness	0.95	0.52	0.86
Menhinick	0.46	0.39	0.36
Margalef	1.41	1.66	0.47
Fisher_alpha	1.73	2.01	0.63
Berger-Parker	0.18	0.51	0.38
Site III			
Dominance	0.06	0.28	0.34
Shannon	3.95	3.22	3.37
Simpson	0.54	0.44	0.36
Evenness	0.99	0.86	0.75
Menhinick	0.75	0.44	0.36
Margalef	3.00	1.93	0.62
Fisher_alpha	3.97	2.37	0.79
Berger-Parker	0.11	0.67	0.50
Site IV			
Dominance	0.08	0.09	0.24
Shannon	2.58	2.41	1.09
Simpson	0.92	0.81	0.66
Evenness	0.64	0.48	0.45
Menhinick	0.60	0.55	0.35
Margalef	2.07	1.76	0.47
Fisher_alpha	2.63	2.21	0.63
Berger-Parker	0.29	0.25	0.38
Site V			
Dominance	0.27	0.25	0.22
Shannon	2.00	1.75	1.09
Simpson	0.73	0.75	0.66
Evenness	0.47	0.54	0.44
Menhinick	0.48	0.36	0.32
Margalef	2.11	1.18	0.45
Fisher_alpha	2.61	1.42	0.60
Berger-Parker	0.50	0.42	0.38

*Annual mean

(Table 2). The abundance of crustaceans (ind./l.) as depicted in Figure 2 revealed marked spatial and temporal variations during the study. Thus, Cladocera density ranged from 229 ind./l. at site I to 1118 ind./l. at site V while Copepoda registered its highest density (1089 ind./l.) at site III as against its lowest (264 ind./l.) at site I. Ostracoda, however, recorded its maximum population density (124 ind./l.) at site III.

The most commonly used diversity indices used in ecology are the Shannon (1948) and Simpson (1949) (Buzas and Hayek, 1996; Gorelick, 2006). However, richness and evenness are the components of diversity (Pielou, 1975; Omernik, 2003; Ricotta, 2003; Liu et al., 2008). Simpson index is used to assess the dominance, but fails to provide an idea about species richness. Shannon-Wiener index is expected to determine both diversity characteristics, that is, evenness and richness (Melo, 2008) but does not provide any information on the rare species which, however, are very important in studies of biodiversity. This implies that diversity cannot be estimated just by one indices (Hayek and Buzas, 1997; Purvis and Hector, 2000). Therefore, to overcome these limitations different diversity matrices have been accentuated in literature (Rényi, 1961; Daroczy, 1970; Aczel and Daroczy, 1975; Patil and Taillie, 1982).

While assessing the crustacean community of Wular Lake during the entire study period, dominance was maximum for site I (0.38) and minimum (0.06) for site III, reflecting complete dominance of few species at site I. In biological communities, Shannon-Wiener diversity index varies from 0 to 5. According to this index, values less than 1 characterize heavily polluted condition, and values in the range of 1 to 2 are characteristics of moderate polluted condition while the value above 3 signifies stable environmental conditions (Stub et al., 1970; Mason, 1988). In the present study, Shannon Wiener index varied from a lowest of 0.79 at site I to a highest of 3.95 at site III as regards Cladocera. Evenness index, however, varied from a minimum of 0.44 at site V to a maximum of 0.99 at site III. During the entire study, parallel relationship of Shannon-Wiener diversity index with high evenness index was observed, reflecting the close correlation of these two indices ($r = 0.717$; $P<0.01$) (Balloch et al., 1976).

Generally, Simpson index ranges from 0 to 1. Mature and stable communities have high diversity value (0.6 to 0.9), while the communities under stress conditions, exhibiting low diversity, usually show close to zero value (Dash, 2003). Simpson diversity index is always higher where the community is dominated by less number of species and when the dominance is shared by large number of species (Whittaker, 1965). In the present study, Simpson index varied from 0.22 at site I to 0.92 at site IV and as such site I experienced larger anthropogenic pressures. The present study also indicates that whenever Simpson diversity index increases towards higher value, the evenness index goes in antagonistic directions and vice versa. Therefore, there seems to be an inverse relationship between the two (Table 3; r =

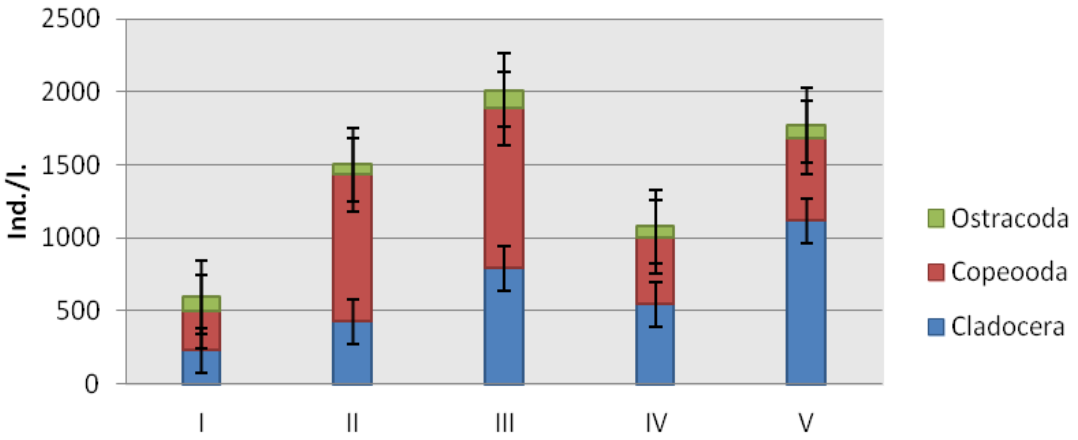

Figure 2. Crustacean population density at five sampling sites in Wular Lake during September 2010 to August 2011.

Table 3. Inter-correlation between various indices based on Pearson coefficient

	Dominance	Shannon	Simpson	Evenness	Menhinick	Margalef	Fisher_alpha
Shannon	-.668(**)						
Simpson	-.419(*)	.619(**)					
Evenness	-.334	.717(**)	-.540(*)				
Menhinick	-.784(**)	.616(**)	.501	.507(*)		.	
Margalef	-.577(*)	.663(**)	.345	.484(*)	.901(**)		
Fisher_alpha	-.597(**)	.673(**)	-542(*)	.500(*)	.922(**)	.998(**)	
Berger-Parker	-.844(**)	.004	-.113	-.578(**)	-.622(**)	.612(*)	-.346

** Correlation at 0.01(2-tailed)... * Correlation at 0.05(2-tailed).

0.540; P< 0.05) (Walting et al., 1979). The results as depicted by the same index were found highly correlative with Shannon index (r = 0.619; P = 0.01) during the present study (Türkmen and Kazanci, 2010).

Margalef index has no limit value and it shows a variation depending upon the number of species. Thus, it is used for comparison of the sites (Kocatas 1992) and takes only one component of diversity (species richness) into consideration reflecting sensitivity to sample size. The only advantage of this index is that we can compare the richness of different study sites over the Simpson index and that the values extend beyond 1 which is unlike the Simpson index where the values range from 0 to 1. In the present investigation, the values of Margalef diversity index were between 0.44 at site I and 3.0 at site III. Menhinick index, like Margalef's index, attempts to estimate species richness but at the same time it is independent on the sample size. In the present investigation, it ranged from 0.30 for site I to 0.75 for site III. The low diversity associated with site I, as ascribed by the Shannon, Margalef and Menhinick indices, may be attributed to lesser number of species and environmental degradation due to anthropogenic pressures, besides other biotic factors (Ravera, 2001). Berger-Parker index was highest for Copepoda at site III (0.67) while it turned to be lowest for Cladocera (0.11) at the same site, signifying the fact that the higher the value of Berger-Parker index, the higher the diversity and lower the dominance. In contrast to the above two indices (Menhinick and Margalef's indices), the Berger-Parker index depends completely on evenness, and is simply the inverse of the proportion of individuals in the community that belong to the single most common species. Therefore, it depends on the sensitivity to sample size as Margalef's index.

Fisher_alpha is the only diversity index that reveals spatial and temporal distribution pattern of a species (Rosenzweig, 1995) and is preferred because it has low sensitivity towards the sample size and is relatively insensitive to rare species (Kempton and Taylor, 1974; Magurran, 1988). Unlike that of Menhinick index, it is independent on sample size. However, indices like Margalef and Berger-Parker tend to have very high sensitivity towards sample size. Fisher's alpha may be seen as a measure of species richness in comparison to Simpson index that is a measure of evenness (r = 0. 542; P = 0.05) (Gonzalez et al., 2010). During the entire study, the highest value of Fisher_alpha (3.97) was evinced for site III while the lowest value (0.58) was registered at site I.

Like Shannon index, this index does not provide any information regarding the rare species in the population (Magurran, 1988).

Conclusions

The information depicted by majority of diversity matrices can be used to determine (i) ecological amplitude of organisms (habitat qualities) (ii) community structure in terms of quantitative analysis (species richness, evenness) and their interactions with the biotic or abiotic factors prevailing in the area. Many diversity indices have high diversity values for stable communities while the unstable ones have low values due to environmental degradation so that environmental reliability can be highlighted. In the light of the above discussed facts it can be inferred that Shannon-Weiner and Simpson diversities increases as richness increase for a given pattern of evenness, and increase as evenness increases for a given richness, but they do not always follow the same trend. Simpson diversity is less susceptible to richness and more sensitive to evenness than Shannon index which in turn, is more responsive to evenness. At the other extreme, a third index in this group, the Berger-Parker index, depends exclusively on evenness; it is simply the inverse of the proportion of individuals in the community that belong to the single most common species, while the other indices (Margalef and Menhinick) are dependent on the number of species. Eventually, the options of index to be used depend on the constraints of the researcher and the value that the index reflects the quantitative interpretation and understanding of the study under investigation.

ACKNOWLEDGEMENT

Thanks are due to the Director, Centre of Research for Development and Head, Environmental Science, University of Kashmir for providing necessary laboratory facilities.

REFERENCES

Aczel J, Daroczy Z (1975). On Measures of Information and their Characterization. Academic Press, New York.

Auclair AN, Goff FG (1971). Diversity relations of upland forests in the western Great Lakes area. Am. Natur., 105:499-528.

Balloch D, Davies CE, Jones FH (1976). Biological assessment of water quality in three British rivers: The North Esk (Scotland), thelevel (England) and the Toff (Wales), Water Pollut. Control, 75:92-114.

Berger WH, Parker FL (1970). Diversity of planktonic Foraminifera in deep sea sediments. Science, 168:1345-1347.

Buzas MA, Hayek LAC (1996). Biodiversity resolution: An integrated approach. Biodiversity Letters, 3:40-43.

Charles DF, Acker FW, Hart DD, Reimer CW, Cotter PB (2006). Large-scale regional variation in diatom-water chemistry relationships: Rivers of the eastern United States. Hydrobiologia, 561:27–57.

Coleman MA (2002). Small-scale spatial variability in intertidal and subtidal turfing algal assemblages and the temporal generality of these patterns. J. Exp. Mar. Biol. Ecol., 267:53–74.

Daroczy Z (1970). Generalized information functions. Information and Control, 16:36-51.

Dash MC (2003). Fundamental of Ecology. 2nd Edition Tata McGraw-Hill publishing company limited, New Delhi.

Edmondson WT (1992). Ward and Whiple Freshwater Biology. 2nd ed. Intern. Books and Periodicals Supply Service, New Delhi.

Fisher RA, Corbet AS, Williams CB (1943). The relation between the number of species and the number of individuals in a random sample of an animal population. J. Anim. Ecol. 12:42–57.

Gonzalez MA, Roger A, Courtois EA, Jabot F, Norden NCE, Paine T, Baraloto C, Christophe T, Chave J (2010). Shifts in species and phylogenetic diversity between sapling and tree communities indicate negative density dependence in a lowland rain forest. J. Ecol. 98:137–146.

Gorelick R (2006).Combining richness and abundance into a single diversity index using matrix analogues of Shannon's and Simpson's indices. Ecography, 29:525-530.

Guerold F (2000). Influence of taxonomic determination level on several community indices. Water Res. 34:487–492.

Hayek LC, Buzas MA (1997). Surveying Natural Populations. Columbia University Press, New York.

Johnson MP, Raven PH (1970). Natural regulation of plant species diversity. Evol. Biol. 4:127-162.

Kempton RA, Taylor LR (1974). Log-series and log-normal parameters as diversity determinants for the Lepidoptera. J. Anim. Ecol. 43(2):381-399.

Kocatas A (1992). Ekoloji ve Çevre Biyolojisi. Ege Üniv. Matbaası, İzmir, p.564s.

Liu ZF, Liu GH, Fu BJ, Zheng XX (2008). Relationship between plant species diversity and soil microbial functional diversity along a longitudinal gradient in temperate grasslands of Hulunbeir, Inner Mongolia, China. Ecol. Res. 23:511–518.

Magurran AE (1988). Ecological Diversity and its Measurement. Croom Helm, London, p.179.

Margalef R (1968). Perspectives in Ecological Theory. University of Chicago Press, Chicago, IL, p.111.

Mason CF (1988). Biology of Fresh Water Pollution. Longman scientific and technical.

McIntosh RP (1967). An index of diversity and the relation of certain concepts to diversity. Ecology, 48:392-404.

Melo AS (2008). What we win "confounding" species richness and evenness in a diversity index? Biota Neotropica, 8:021-027.

Menhinick EF (1964). A comparison of some species-individuals diversity indices applied to samples of field in-sects. Ecology, 45:859-861.

Norris RH, Georges A (1993). Analysis and interpretation of benthic macroinvertebrate surveys. In: Freshwater Biomonitoring and Benthic Macroinvertebrates (Rosenberg D,M and Resh V.H. eds.). Chapman and Hall, New York. pp. 234–286.

Omernik JM (2003). The misuse of hydrologic unit maps for extrapolation, reporting, and ecosystem management. Jour. Am. Water Resources Assn., 39(3):563-573.

Patil GP, Taillie C (1982). Diversity as a concept and measurement. J. Am. Statist. Assoc. 77:548-561.

Pennak RW (1978). Freshwater Invertebrates of United States of America. Wiley Interscience Pub., N. Y.

Pielou EC (1975). Ecological Diversity. John Wiley and Sons, New York.

Pielou EC (1969). An Introduction to Mathematical Ecology. Wiley and Sons, New York.

Purvis A, Hector A (2000). Getting the measure of biodiversity. Nature, 405:212-219.

Ravera O (2001). A comparison between diversity, similarity and biotic indices applied to the macroinvertebrate community of a small stream: The Ravella river (Como Province, Northern Italy). Aquatic Ecol. 35:97–107.

Rényi A (1961).On measures of entropy and information. p. 547-561. In: Proceedings of the Fourth Berkeley Symposium on Mathematical Statistics and Probability, (G. Neyman, ed.). University of California Press, Berkeley.

Ricotta C (2003). On parametric evenness measures. J. Theoretical Biol. 22:189-197.

Rindi F, Battelli C (2005). Spatio-temporal variability of intertidal algal assemblages of the Slovenian coast (Gulf of Trieste, northern Adriatic Sea). Bot. Mar. 48:96–105.
Risser PG, Rice EI (1971). Diversity in tree species in Oklahoma upland forests. Ecology, 52:876 – 880.
Rosenzweig ML (1995). Species Diversity in Space and Time. Cambridge University Press, Cambridge, UK.
Schmitz A, Nadel R (1995). Influence of 3,4-dichloroaniline (3,4- DCA) on benthic invertebrates in indoor experimental streams. Ecotoxicol. Envir. Safety, 30:63–71.
Shah JA, Pandit AK, Shah GM (2013). Distribution, diversity and abundance of copepod zooplankton of Wular Lake, Kashmir Himalaya, J. Ecol. Nat. Environ. 5(2):24-29.
Shah JA, Pandit AK (2013). Relation between physico–chemical limnology and crustacean community in Wular lake of Kashmir Himalaya, Pak. J. Biol. Sci. 16(19):976-983.
Shannon CE, Wiener W (1949). The Mathematical Theory of Communication. Urbana, University of Illinois Press, p.177.
Simpson EH (1949). Measurement of diversity. Nature, 163:688.
Soininen J (2007). Environmental and spatial control of freshwater diatoms – a review. Diatom Research, 22:473–490.
Southwood TR (1978). Ecological Methods With Particular Reference to the Study of Insect Populations. 2nd ed. Chapman and Hall, London, p.524.
Stub R, Appling JW, Hatstetter AM, Hass IJ (1970). The effect of industrial waste of Memphis and Shelby country on primary planktonic producers. Bioscience, 20:905-912.
Türkmen G Kazanci N (2010). Applications of various biodiversity indices to benthic macroinvertebrate assemblages in streams of a national park in Turkey. Rev. Hydrobiol. 3(2):111-125.
Underwood AJ, chapman MG (1996). Scales of spatial patterns of distribution of intertidal invertebrates. Oecologia, 107:212–224.
Van Dam H, Mertens A, Sinkeldam J (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Netherlands J. Aquatic Ecol. 28(1):117-133.
Watling K, Bottom G, Pembroke A, Maurer D (1979). Seasonal variations in Delaware Bay phytoplankton community structure. Mar. Biol. 53:207-215.
Whittaker RH (1965). Dominance and diversity in land plant communities. Science (Washington, D.C.), 147:250–260.