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REVIEW

SILENT WITNESS OF WATER POLLUTION: BIOINDICATOR FRESHWATER INVERTEBRATES

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ABSTRACT

During the last years, not only industrial activities, but also anthropogenic activities have had negative consequences for the freshwater ecosystems. All aquatic organisms accumulate organic or inorganic elements in their bodies whether or not these elements are essential to metabolism. Community compositions of freshwater invertebrates such as gastropods, oligochaetes and chironomids, reflect the states and changes in aquatic ecosystems. Many factors regulate the occurrence and distribution of these organisms. The most important of these factors are physical and chemical characteristics of water. Members of the invertebrates groups, due to their capacities to increase in number with increasing organic matter or to replace other benthic invertebrates that are less tolerant for a particular condition, have been universally applied on bioassessment assays as indicators of the pollution in freshwater systems. Members of these groups can also show some taxonomic variations against polluters and many researchers may not know these variations and make mistake in identification using the existing identification keys.

Key words: Freshwater pollution, macroinvertebrates, gastropods, oligochaetas, chironomids

SU KİRLİLİĞİNİN SESSİZ ŞAHİTLERİ: BİOİNDİKATÖR TATLISU OMURGASIZLARI

ÖZET

Son yıllarda, hem endüstriyel hem de antropojenik aktiviteler akarsu ekosistemleri için negatif etkilere neden olmaktadır. Bütün sucul organizmalar, metabolizmaları için gerekli olsun ya da olmasın organik ya da inorganik elementleri vücutlarında biriktirirler. Gastropodlar, Oligoketler ve Chironomidler gibi akarsuların omurgasız komünite üyeleri, sucul ekosistemlerdeki durumu ve değişimleri yansıtırlar. Birçok faktör, bu organizmaların o ortamda bulunuşunu ve dağılışını düzenlemektedir. Bu faktörlerden en önemlisi, suyun fiziksel ve kimyasal özellikleridir. Omurgasız grup üyelerine, artan organik kirliliğe karşı sayıca artış ya da belirli şartlara daha az toleranslı diğer bentik omurgasızlarla yer değiştirme kapasitelerinden dolayı; akarsu sistemlerindeki kirlilik indikatörleri olarak biyolojik değerlendirme çalışmalarında evrensel olarak başvurulmaktadır. Bu grubun üyeleri, kirleticilere karşı bazı taksonomik varyasyonlar da gösterebilir ve birçok araştırmacının bu varyasyonlar konusunda bilgisi olmayıp var olan teşhis anahtarlarını kullanarak yanlış teşhisler yapabilir.

Anahtar kelimeler: Akarsu kirliliği, makroomurgasızlar, gastropodlar, oligoketler, chironomidler

INTRODUCTION

Bioindicators are organisms or communities of organism, reactions of which are observed representatively to evaluate a situation clues for the condition of the whole ecosystem. A general definition of a biological indicator is that a species or a group of species readily reflect abiotic or biotic state of an environment and, represent impacts of environmental changes on habitat, community or ecosystem or is indicative of the diversity of a subset of taxa or the whole diversity within an area (Rinderhagen et al. 2000). Although some freshwater invertebrates (such as Ephemeroptera, Plecoptera and Trichoptera) are considered as highly sensitive to organic pollutions, some certain species of aquatic invertebrates [*(Gastropoda (Physa acuta, Potamopyrgus antipodarum, Lymnaea stagnalis)*; Annelida (*Limnodrilus* spp., *Tubifex* spp., *Potamothrix* spp. and some insects (*Chironomus* spp.), Figure 1] are widely considered as tolerant (even extremely tolerant) to organic pollution, capable of surviving anoxic conditions due to the presence of haemoglobin (especially oligochaetes and chironomids). These organisms are frequently used as both bioindicators and biomonitors in various aquatic systems (Rinderhagen et al. 2000) as benthically and/or epibenthically living aquatic invertebrates are exposed directly to the effects of elements in both water and sediment (Burton 1992, Timmermans et al. 1992). Furthermore, these so-called species ‘‘sentinel’’ organisms accumulate and concentrate pollutants from their surroundings and/or food, and hence a regular analysis of their tissues provides a time-integrated estimate of the environmentally available concentrations of these pollutants. In addition, they are a very successful group with an immense variety of ecological types living in a great number of different habitats. However, benthically and/or epibenthically living aquatic invertebrates undergo morphological deformities when in contact with sediment contaminated with chemicals. Especially, Chironomidae and Oligochaete groups show some morphological variations against pollution. When researchers attempt to identify these species using the current keys, they may make many mistakes because these morphological variations does not take part in these keys. So, the current identification keys could be insufficient for particularly young researchers.

EXPOSITION

Presently, freshwater resources are under effects of intensive polluters in all around the world. The influences of freshwater pollution on freshwater invertebrates have been studied by many authors. Several studies showed that members of these groups mentioned above, have been universally applied on bioassessment assays as bioindicators to reflect the organic pollution in rivers and streams (Lin and Yo 2008) because of their capacities to increase in number with increasing organic matter or to replace other benthic macroinvertebrates that are less tolerant for a particular condition (Schenková and Helešic 2006). For example; Martins et al. (2008) carried out a study about Tubificidae (Oligochaeta) as an indicator of water quality in an urban stream in southeast Brazil. They used some biotic indices such as density of Tubificidae, percentage of *L. hoffmeisteri* and Modified Howmiller and Scott Environmental Index. Their data confirmed Tubificidae as an effective biological indicator of stream conditions (Martins et al. 2008). Arslan et al. (2010) conducted a study in Lake Uluabat, a Ramsar Site of Turkey, about metal contents in water, sediment, and Oligochaeta-Chironomidae. They indicated that certain species of oligochaetes and chironomids can accumulate cadmium, chromium, lead, copper, nickel, and zinc at levels several times higher compared to their surroundings. They concluded that the oligochaetes and chironomids are suitable candidates to be used in biomonitoring surveys of Lake Uluabat (Arslan et al. 2010). A study carried out by Lencioni et al. (2012) indicated that some species were significantly associated with a specific stressor. *Macropelopia* spp., *Diamesa aberrata, Chaetocladius vitellinus* gr., *Limnophyes* spp., and *Micropsectra notescens* gr. indicated pasture; *Pseudokiefferiella nubeculosum* indicated agriculture; *Chaetocladius perennis, Limnophyes* spp., and *Gymnometriocnemus* sp. indicated water captation; *Krenopelopia* sp., *Chaetocladius dentiforceps* gr., *Heterotrissocladius apicalis*, and *Limnophyes* spp. indicated a bed modification (Lencioni et al. 2012). Özdemir et al. (2010) tested a fresh water oligochaete, *Limnodrilus profundicola*, as a bioindicator of potential. They reported that although *L. profundicola* has a reputation for being very resistant to pollution, it may potentially be used as a bioindicator species for contaminant exposure when cholinesterase and ethoxyresorufin-

O-deethylase are used as biomarkers (Özdemir et al. 2010). Shuhaimi-Othman et al. (2012) studied heavy metal toxicity on an aquatic worm, *Nais elinguis* (Oligochaeta, Naididae). When they compared LC_{50} values of *N. elinguis* for heavy metals with other freshwater worms, it was revealed that *N. elinguis* was equally or more sensitive to metals. Their study indicated that *N. elinguis* is a potential organism in toxicity testing and a bioindicator of heavy metal pollution (Shuhaimi-Othman et al. 2012). Ravera (1991) reported that the experiments carried out with various metals (Cd, Pb, Ni, Hg, V) in freshwater pulmonates mainly on *Biomphalaria glabrata* and *Physa acuta* and, but only a few studies involved *Lymnaea stagnalis* with nickel and *Radix auricolaria japonica* with lead.

Gomot (1998) studied toxic effects of cadmium on reproduction, development, and hatching of a freshwater snail *L. stagnalis* for water quality monitoring. Her data demonstrated the effects of Cd^{+2} on reproduction and development in *L. stagnalis* and provided valuable information on the target response (neuroendocrine control of laying or cell multiplication and organogenesis of the embryos) (Gomot 1998). The success of gastropoda, oligochaeta and chironomid members in evaluation of a wide range of trophic conditions of aquatic ecosystems is attributed to their great capacity for physiological adaptations, allowing the individuals to live in variying environmental conditions including temperature, pH, dissolved oxygen concentration, pollution, salinity, depth, and productivity (Helson et al. 2006, Entrekin et al. 2007). As a result, these organisms are able to intensively colonise on many types of substrates (Berg and Hellenthal 1992, Huryn and Wallace 2000). These characteristics make chironomids efficient organisms for the evaluation of water quality (Takahashi et al. 2008).

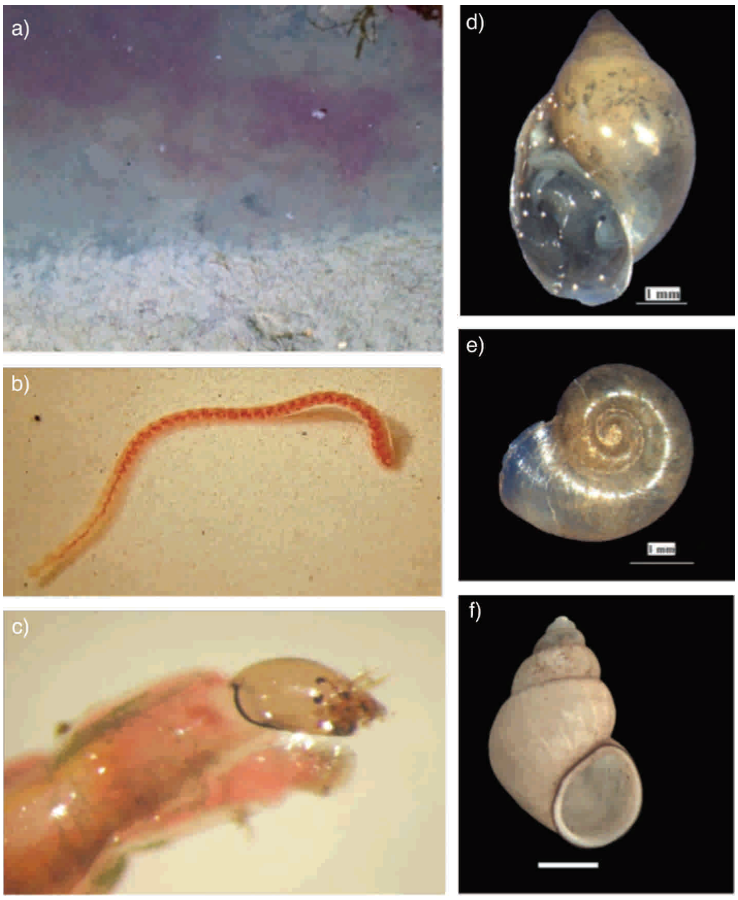

Figure 1. Samples of freshwater invertebrates; a-Intense population of Oligochaeta member at the bottom of a river; b-*Limnodrilus hoffmeisteri (*Oligochaeta*)*; c-Chironomidae larvae*;* d- *Physa acuta (*Gastropoda*)*; e- *Gyraulus piscinarum (*Gastropoda*)*; f-*Potamopyrgus antipodarum (*Gastropoda*)*.

CONCLUSION

Generally, the quality of an aquatic system is determined using water chemistry and physical parameters. But this does not provide a comprehensive view of conditions over time. Freshwater invertebrate communities and in-stream habitats may give better overall pictures of conditions in an aquatic system than changes in physical and chemical parameters. Because macroinvertebrate families vary in their sensitivities to pollution, their relative abundances are used to infer the nature, load and severity of contamination. Macroinvertebrates possess certain advantages, for example, as the group is so diverse, it is possible that some members will respond to pollution; and some members have long life histories allowing the observation of temporal changes in communities and the pollution to which they are responding (Ziglio et al. 2006). From the preceding review, it is evident that the composition and distribution of macroinvertebrates in a freshwater system are governed by numerous physical, chemical and biological factors which should be taken into consideration in any study of stream macroinvertebrates. In addition, it may be said that the composition and distribution of stream macroinvertebrates is a reflection of the aquatic system health, and they can be used as effective bioindicators. Identification of Gastropoda members is easier than Oligochaeta and Chironomidae members while identification of Bithyniidae species are too difficult. Hydrobiidae, Valvatidae and Physidae groups are tolerant to pollution, but there are some problems about distributions in Turkey and taxonomic identification. Identification of Chironomidae members is relatively easy. But they show some taxonomic character variations in response to pollution, and these variations could cause confusion. Young researchers use I., II., and III. instars for identification, and can make wrong identifications because of the use early period of samples. Identification of Oligochaeta members is difficult. They show many morphological variations against pollution. So, many researchers do not know these variations and make many mistakes during identification of these samples.

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