E.Ü. Su Ürünleri Dergisi 2008
E.U. Journal of Fisheries & Aquatic Sciences 2008
Cilt/Volume 25, Sayı/Issue (1): 47–51


ISSN 1300 - 1590
http://jfas.ege.edu.tr/

# Sediment Toxicity of Streams Flow through the Inner Part of İzmir Bay with *Daphnia magna* Straus, 1820

Özcan Yegane, *Hatice Parlak, Özlem Çakal Arslan, Meltem Boyacıoğlu

*Ege University, Faculty of Fisheries, Hydrobiology Dept., Bornova, İzmir, Türkiye*
**E mail: hatice.parlak@ege.edu.tr*

**Özet:** ***İzmir İç Körfezi'ne dökülen derelerin* Daphnia magna *Straus, 1820 ile sediment toksisitesi.*** Bu çalışmanın amacı İzmir Körfezi'ne dökülen derelerin sediment toksisitesini su piresi *Daphnia magna* kullanarak izleyebilmektir. Toplanan sedimentlerin toksik içeriği saf su ile elüsyondan sonra belirlenmiştir. Elusyonların letal toksisitesi 192-s akut toksisite testi ile belirlenmiştir. Akut testlerde hareketsizlik indis olarak kullanılmıştır. Kronik testlerde hayatta kalma, ilk üreme günü, anaç başına yumurta ve yavru sayıları indis olarak kullanılmıştır. Akut test sonuçlarına göre $LC_{50}$ (192-s) değerleri yaklaşık olarak Melez, Halkapınar, Manda dereleri için %79.025, %57.321, %81.603 olarak hesaplanmıştır. Bornova deresi diğer istasyonlarla karşılaştırıldığında, belirlenen $LC_{50}$ (1.5 saat) %67.273 değeri ile daha toksik bulunmuştur. Sub-letal sediment elusyonu seyrelmelerine maruz bırakılan *D. magna* testi sonuçları ise tüm elusyonların pozitif etki yarattığını göstermiştir (hormeosis). Bu çalışmada elde edilen veriler *D. magna* kullanılarak yüzey sularının kirliliğinin daha iyi ve anlamlı bir şekilde belirlenebileceğini göstermektedir.

**Anahtar Kelimeler:** Sediment Toksisitesi*, Daphnia manga*, Akut toksisite, Kronik Toksisite.

**Abstract:** The aim of this study is to screen the sediment toxicity of streams that flow into the inner part of Izmir Bay by using the water flea *Daphnia magna* Straus as a test organism. The toxic contents of collected sediments were elutriated by pure water. The lethal toxicity of elutriates were evaluated by using the 192- h acute toxicity test. Immobilization was used as indices in acute tests. Survival age at first reproduction, number of brood produced and the number of young per adult were used as indices in chronic test. According to acute test results calculated $LC_{50}$ (192-h) were 79.025% 57.321%, 81.603%, for Melez, Halkapınar, Manda streams respectively. The diluted elutrates were of Bornova Stream were the most toxic among the others as $LC_{50}$ (1.5 hour) 67.273%. *D. magna* were exposed to sub-lethal dilutions of sediment elutriates and the results show that all of elutriates produced positive effects (hormeosis). Results of this study showed that, screening the toxicity of polluted waters by using *D. magna* gives better and more meaningful results to predict the pollution of surface waters.

**Key Words:** Sediment toxicity, *Daphnia manga*, Acute toxicity, Chronic toxicity.

## Introduction

Izmir Bay located in western Turkey is surrounded by a densely populated community. Inner Bay, which is intensely industrialized (mainly iron, paper, antifouling paints, chlorine-alkali plants, cement factories, beer industries and a busy harbour) compared to the middle and outer parts of the bay. The main sources of pollution are streams due to municipal, industrial and nonpoint source waste discharges to streams and hundreds of small domestic discharge outlets which flow into the bay (Kucuksezgin et al. 2008). The researches on the toxic effects of sediments of the stream have a great importance to solve environmental problems of Izmir Bay.

The significant role that sediment plays in aquatic ecosystem is well known. They serve as both a sink for contaminants introduced into surface waters and a source of organic and inorganic materials, where critical cycling processes for organic matter and the critical elements. Concentrating these materials to much higher levels than in the water (Burton, 1991). Studies of aquatic ecosystems should therefore not be limited to the water column, but must also consider the sediment quality.

Bioassays with sediments can be used to determine the bioavailability of analyzed concentrations of contaminants in order to assess their pollutant potential. The toxicity of fresh water sediments has been assessed with the use of various fresh water invertebrates (Ingersoll et al. 1995). The Cladoceran *Daphnia magna* Straus, although not a sediment-dwelling organism, has shown its usefulness in evaluating fresh water sediment toxicity (Nebeker et al. 1984).

*Daphnia magna* is one of the most important fresh water species employed in ecotoxicity testing through the world. *Daphnia magna* has been used extensively to determine the toxicity of effluents, water and sediment samples and has been demonstrated to be sensitive to many environmental contaminants. Daphnids are important invertebrate species in aquatic food webs. Most daphnids are cyclic parthenogenetic species capable of both asexuel and sexuel reproduction. Sexuel reproduction is used to produce sufficient numbers of resting eggs known as ephippia. Resting eggs require the presence of males for fertilization and development. Laboratory cultures of Daphnids are typically maintened in partenogenetic state.

The aims of this study is to define the toxicity of sediments from certain streams that flow through the inner Izmir Bay by using the water flea *Daphnia magna* Straus as a

test organism and to prove the appropriateness of this test system for routine studies to determine sediment toxicity.

## Material and Methods

Sediment bioassays have usually been applied to sediments from sites close to known sources of pollution such as major industrial sites. In this study sediment bioassay were conducted on samples from 4 streams that flow through inner Izmir Bay. These are: Melez Stream, Manda stream, Halkapinar stream and Bornova stream (Figure 1). Sediment were taken by Van-Veen Grab and corer in November 1999 and stored at 4$^{0}$C.

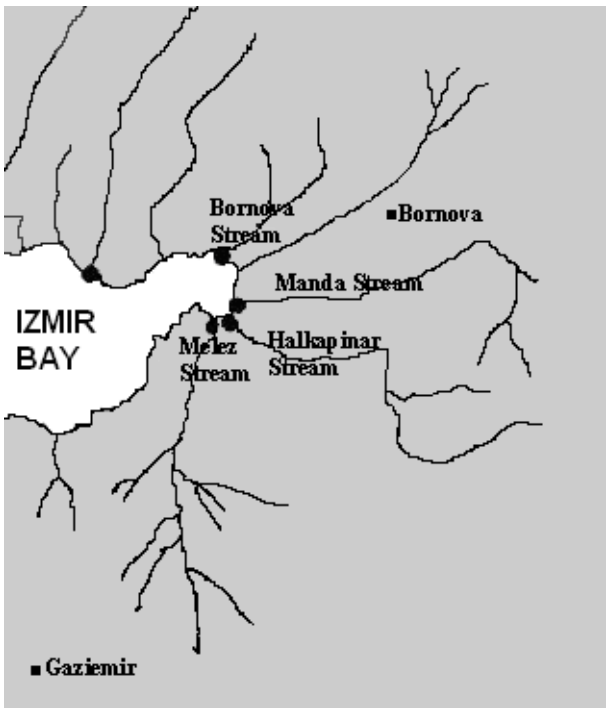


**Figure 1**. Sampling stations on the streams flowing to the inner part of Izmir Bay

The toxic contents of collected sediments were diluted by mixing 500 ml of sediment with 2000 ml of hard water and then the lethal toxicity of elutriates were evaluated by using the 192h acute toxicity test. Sub-lethal toxicity of elutriates were evaluated with a 7 day chronic toxicity test.

The acute toxicity of sediment elutriates ranging in from %10 to%100 to daphnids was determined during 192 h exposure of neonatal daphnids (<24h old at the innitiation of exposure). The daphnids were exposed in 1000-ml beakers containing ten daphnids. 24 hours old daphnids were exposed to elutriates of sedimet collected from 4 stream flow throught inner Izmir Bay. The test was maintained at 20 to 22$^{o}$C. A 16-h light: 8- h dark photoperiod.

In the chronic toxicity study, daphnia (10 days old) were exposed to a range of sediment elutriates under semi-static conditions with renewal of test solutions every 76 h and 120 h. The daphnia were fed by daily addition of algae and yeast suspensions. Ten beakers per treatment group were used with one daphnid per beaker. During the experiments, temperature, dissolved oxygen, pH, and total hardness were monitored weekly. Endpoints included adult survival, age at first reproduction, number of egg per individual, number of live neonates per individual, and total number of young per adult. For this purpose the neonates were collected and counted every day. The egg numbers in were counted up 5 eggs and if the number is more than 5, it was recorded as >5.

*Daphnia magna* Straus cultured at 20 to 22$^{o}$C. A photoperiod of 16-h light: 8- h dark was maintained for culturing and testing. Culture water was changed two to three times per week. The daphnia were fed 75x106/ml cells the unicellular green algae *Selenastrum copricornutum* was cultured in Bristol medium. These culture conditions maintained the daphnids in the parteogenetic reproductive stage.

The $LC_{50}$'s were calculated by probit analysis using Toxicologist (1.00-June 1990) statistical software. All chronic data were tested for statistical significance using a single factor one-way analysis of variance (ANOVA).

## Results

Sediment bioassay with daphnia 5 concentration was used (10, 25, 50, 75 and 100% sediment elutriate). The summary of 192-h acute toxicity of sediments of 4 streams presented in Figure 2. In this study the 95% confidence limits overlap and dose-response relationship ($x^2$=0,01- 2,6) were defined. Sediments in major streams of the Izmir Bay were found to be toxic in the test.

Sediment toxicity to daphnia as $LC_{50}$ after 192-h exposure ranged from 57% to 79% in sediment and $LT_{50}$ for sediment elutriate (50, 75 and 100%) ranged from 2-h 168-h. The 192-h acute test results, average $LC_{50}$ for *D. magna* was calculated as 79.025%, 57.321%, 65.477%for Melez, Halkapinar and Manda streams respectively. An average $LC_{50}$ of Bornova stream was calculated as 62.273% for a time as short as 1.5 hours. (Table 1). Results showed that Bornova stream is more toxic than the others because of the observing their lethality (50%) as short as 1.5 hours.

It can be concluded that comparing $LC_{50}$ levels of the elutrate dilutions the toxicity order is Bornova>Halkapınar >Manda>Melez.

The effect of four stream's sediment on daphnids survival and reproduction was investigated in 7-day chronic studies.

Chronic toxicity tests with daphnia 4 dilution was used (50, 60, 70 and 80% elutriate of sediments). Adult survival was %100, %100, %90 and%80 in the dilution of elutriate %50, %60, %70 and %80 respectively from Melez stream. Adult survival in Halkapinar stream was %100 and %90, Manda stream was %100 and no adult mortality was observed in the Bornova stream (Table 2).

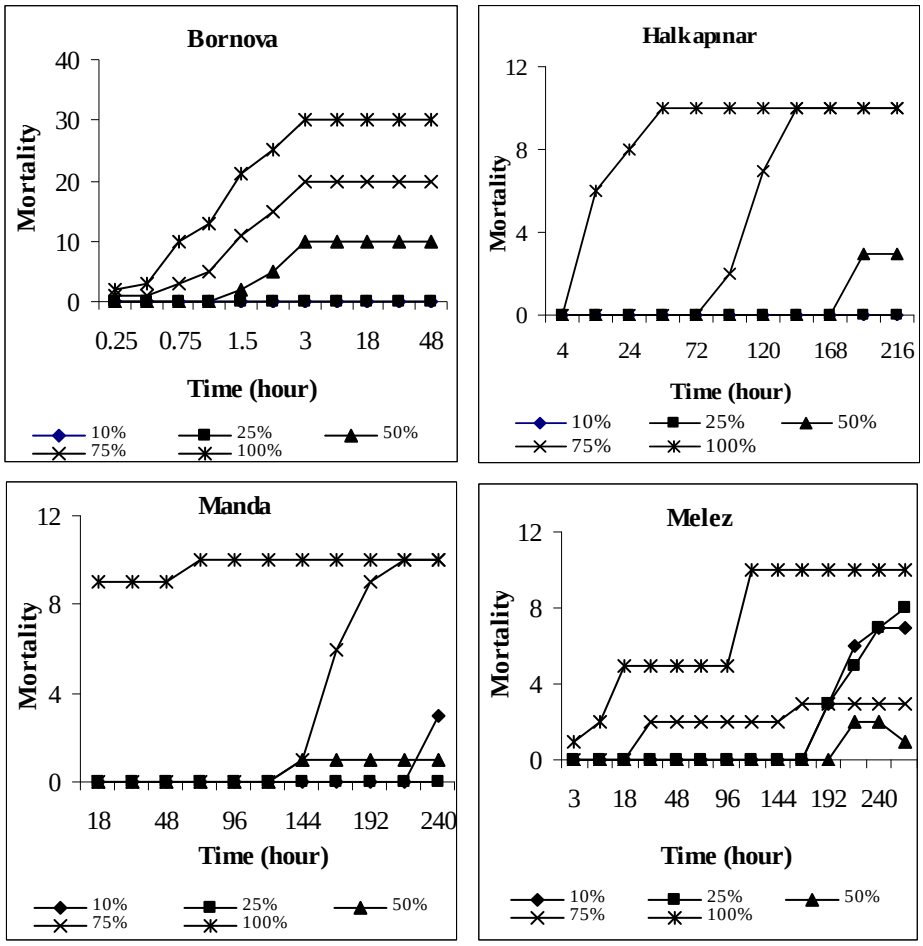


**Figure 2.** Mortality of *D.magna* exposed to the diluted elutriates of the sediments from Melez, Manda, Halkapınar, Bornova streams flowing through the inner bay of Izmir.

**Table 1.** Sublethal effects of the diluted elutriates of sediments from Melez, Manda, Halkapınar and Bornova streams flowing through to Izmir Bay. *Statistically significant increase comparing to controls p<0.05, **p<0.005.

| % Elutriate | Parameter | | | | |
|---|---|---|---|---|---|
| | Survival | First Reproduction day | Total number of eggs per individual | Total number of molts per individual | Total numbers of neonates |
| Control | 100 | 13,10 | 05,90 | 11,40 | 114 |
| **Melez** | | | | | |
| %50 | 100 | 13,20 | 07,70 | 07,30** | 73** |
| %60 | 100 | 15,14* | 10,44 | 07,88** | 71** |
| %70 | 90 | 15,57* | 10,00 | 05,87** | 47** |
| %80 | 80 | 16,33* | 09,66 | 06,50** | 48** |
| **Halkapinar** | | | | | |
| %25 | 100 | 13,40 | 13,90* | 14,90 | 149* |
| %35 | 100 | 13,33 | 12,88* | 18,33 | 165* |
| %45 | 90 | 13,55 | 12,25* | 15,62 | 125* |
| %60 | 100 | 13,44 | 10,22* | 09,22 | 87 |
| **Manda** | | | | | |
| %25 | 100 | 14,40 | 15,50* | 12,20 | 122 |
| %30 | 100 | 14,88 | 10,87* | 09,37 | 75** |
| %35 | 100 | 13,87 | 14,12* | 12,62 | 101 |
| %40 | 100 | 15,60* | 10,16* | 07,66** | 46** |
| **Bornova** | | | | | |
| %10 | 100 | 13,60 | 16,50* | 19,90* | 199* |
| %15 | 100 | 14,14 | 15,57* | 20,00* | 140* |
| %20 | 90 | 13,70 | 13,88* | 17,11* | 154* |
| %25 | 100 | 13,77 | 13,88* | 18,44* | 166* |

The results showed that the Melez Stream elutriates produced low survival, and the sediment elutriates from Melez and Manda Stream produced late reproduction time. All of the elutriates from all streams produced positive effects (hormeosis) on the number of brood productions except for Melez's%80 elutriate. The hormeosis effect was observed on the number of young produced with 35% of Halkapınar Stream's elutriate, and the 10% and 15% of Bornova Stream's elutriates. It was also observed that high total suspended solids cause negative effects on vitality of *D. magna*.

## Discussion and Conclusion

Two test designs were used in this study. Lethal Effects (lethality) of sediment were determining with acute tests and, sub-lethal effects (survival, reproduction, immobility, first reproduction, fertility) were investigated chronic tests.

*Daphnia magna* is one of the most important fresh water species employed in ecotoxicity testing for effluents, water and sediment samples. In previous researches *D. magna* were exposed to whole sediment, filtered or unfiltered sediment elutriates or sediment pore waters in acute sediment toxicity test (Schuytema et al. 1984, Hall et al. 1986, Giesey et al. 1988, 1990, Ristola et al. 1996). Soucek et al (2000) had reported the 48-h $LC_{50}$ values of pore water and elutriates of sediment samples as 35% and 65% respectively. This results show that the elutriate of the sediment reflects the toxicity of sediments better than pore water.

Bridges et al. (1996) had investigated the toxic effects of the sediments of Great Lakes and reported that the undiluted elutriates were decrease the survival rate up to 50%. Dave and Nilsson (1999) were determining toxic effects of Kattegat and Skagerrak sediments in Baltic Sea using two species *Daphnia magna* and *Nitocra spinipe* and they were founded similar results. Ingersol (1992) found that the acute toxicity of irrigation drain waters to *D. magna*. Bridges et al. (1996) reported that Great Lake sediment elutriates were decreased the survival of adult *D. magna* 50%. Contrary, Ristola et. al. (1996) had recorded that sediment elutriate or pore water tests did not exhibit toxicity to *Daphnia magna* in Lake Ladoga sediments. However, This is in marked contrast to the results of an extensive study by Ankley et. al. (1991), who examined the effects of pore water, elutriate and solid-phase fractions from 29 different sediments on four different species of aquatic organisms. The authors found that pore water bioassays were the most toxic component of the three phases and that, although elutriates were poor predictors of toxicity from contaminated sediment, pore water tests correlated well with bulk sediment toxicity. However, they point out that the solid-phase experiments were, in fact, diluted to a greater extent than pore water tests. The results in the current study support the observed toxicity noted in the freeze-dried sediment.

Much research has been conducted to assess the toxicity of sediments from various 'Areas of Concern' in the Great Lakes basin in North America. In a study, 10 contaminated sites sediment from Hamilton Harbour on Lake Ontario, Canada were examined and they caused extreme toxicity in bioassays containing the zooplankter cladoceran *Daphnia magna* and the benthic amphipod *Hyalella azteca* (McCarthy 1994).

As the result of our study, the diluted elutriates at sublethal level had caused to difference at the first day of reproduction. *D. magna* exposed to the elutriates of Melez and Manda stream had produced eggs lately than controls while Bornova and Halkapınar did not changed. Similarly, Kortelainen (1994) had determined 2 day delay in the firsh reproduction day of *D. magna* exposed to the dilution of the elutriates from Lavilla region. However, Bridges et. al. (1996) had reported the first reproduction day were earlier than controls of D. *magna* exposed to sediment elutriates from12 station among 17 stations in Great Lakes. The difference in the first reproduction day is an important fenomenon for the population size (Cole 1954, Lewontin 1965, Hamilton 1966, Stearn 1976, Roff 1992) and generally it had been accepted that the population size is more sensitive to early first reproduction day (Mertz 1971, Stearns 1976)

On the other hand the number of eggs produced by *D. magna* was increased in all sublethal test dilutions from all stations except 80% dilution of Melez. This is quite familiar situation in the polluted sediments. This situation were reported in many research (Stebbing 1881, Pagano et. al. 1986) and defined as "hormeosis" meaning "stimulated reproduction under the unfavorable conditions". The effect of unfavorable conditions as increased number of egg but the success of hatching was decreased. Bridges (1996) also reported increased number of egg laid in 10 stations of 17.

Results of this study showed that, screening the toxicity of polluted waters by using *D. magna* gives better and more meaningful results than quantitative analyze of toxic matters. Additionally, it is noted that this method is economic, easy to apply and repeatable. In this matter, not only the environmentally polluted waters but also the toxicity of industrial discharge water could be able to be screened by sediment toxicity test using *D. magna.*

## References

Ankley, G.T., M.K. Schubauer-Berigan and J. R. Dierkes. 1991. Predicting the toxicity of bulk sediments to aquatic organisms with aqueous test fractions: pore water versus elutriate. Environ. Toxicol. Chem., 10: 1359-1366.

Bridges, T.S., R.B.Wright, B.R.Gray, A.B. Gibson and T.M Dillon. 1996. Chronic Toxicity of Great Lakes Sediments to Daphnia magna: Elutriate effects on Survival, Reproduction and Population Growth. Ecotoxicology, 5: 83- 102.

Burton G.A. Jr. 1991. Assending the toxicity of freshwater sediments. Environ. Toxicol. Chem., 10: 1585- 1627.

Cole, L.C. 1954. the population consequences of life history phenomena. Q. Rev. Biol., 29: 103- 37.

Dave, G. and E. Nilsson. 1999. Sediment toxicity and contaminants in the Kattegat and Skagerrak. Aquatic Ecosystem Health and Management, 2: 347- 360.

Hall, W.S., K.L. Dickson, F.Y. Saleh and J.H. Rodgers. 1986. Effects of suspended solids on the bioavailability of chlordane to *Daphnia magna*. Arch. Environ. Contam. Toxicol., 15: 529- 34.

Hamilton, W.D. 1966, The moulding of senescence by natural selection. J. Theor. Biol., 12: 12- 45.

Ingersoll, C.G. 1992, Sediment tests In: Editör: G.M. Rand, Fundamentals of aquatic toxicology. Second edition. Effects, environmental fate and risk assessment. Taylor and Francis publ., 231-255.

Ingersoll, C.G., G.T. Ankley, D.A Benoit,. E.L Brunson, G.A. Burtom, F.J. Dwyer, R.A. Hoke, P.F. Landrum, T.J. Norberg-King and P.W. Winger. 1995. Toxicity and bioaccumulation of sediment-associated contaminants using freshwater invertebrates: A review of methods and applications. Environ. Toxicol. Chem., 14: 1885- 1894.

Kortelainen, I. 1994, Effects of river sediment elutriates on *Daphnia magna.* Hydrobiologia, 294: 207 – 213.

Kucuksezgin, F., B.M. Kayatekin, E. Uluturhan, N. Uysal, O. Acikgoz, S. Gonenc. 2008. Preliminary investigation of sensitive biomarkers of trace metal pollution in mussel (*Mytilus galloprovincialis*) from Izmir Bay (Turkey). Environ Monit Assess., 141:339–345.

Lewontin, R.C. 1965. Selection for colonizing ability. In Baker, H.G. and Stebbins, G.L. eds. The genetics of colonizing species, New York: Academic Press. 79- 94.

McCarthy, L. H. 1994. A study of the toxicity of Great Lakes sediment on aquatic organisms. PhD thesis. University of Waterloo, Waterloo, Ontario, Canada.

Mertz, D.B. 1971. Life history phenomena in increasing and decreasing populations. In Patil, G.P., Pielou, E.C. and Waters, W.E. eds. Statistical ecology. H Sampling and modeling biological populations and population dynamics, pp. 361-99. University Park: Pennsylvania State University Press.

Nebeker, A.V., M.A Cairns,. J.H. Gastater, K.W. Malueg, G.S. Schuytema and D.F. Krawczyk. 1984. Biological methods for determining toxicity of contaminated freshwater sediments to invertebrates. Environ. Toxicol. Chem., 3: 617- 630.

Pagano, G., M. Cipollaro, G. Corsale, A. Esposito, E. Ragucci, G.G. Giordano and N.M. Trieff. 1986. The sea urchin: Bioassay for the assesment of damage from environmental contaminants. Community Toxicity Testing, ASTM, STP 920, John Cairns, Jr., Ed., American Society for Testing and Materials, Philadelphia, 66-92.

Ristola, T., J. Pellinen, M. Lepänen and J. Kukkonen. 1996. Characterization of Lake Ladoga Sediment I. Toxic chemicals. Chemosphere, 32 (6): 1165-1178.

Roff, D.A. 1992, The evolution of life histories. New York: Chapman & Hall.

Schuytema, G.S., P.O. Nelson, K.W. Malueg, A.V. Nebeker, D.F. Krawczyk, A.K. Ratcliff and J.H. Gakstatter. 1984. Toksicity of cadmium in water and sediment slurries to *Daphnia magna*. Environ. Toxicol. Chem., 3: 293- 308.

Soucek, D.J., D.S. Cherry and G.C. Trent. 2000. Relative acute toxicity of acid mine dreinage water column and sediments to Daphnia magna in the Puckett's Creek Watershed, Virginia, USA. Arch, Environ, Contam. Toxicol., 38: 305- 310.

Stearns, S.C., 1976. Life history tactics: a review of the ideas. Q. Rev. Biol., 51: 3- 47.

Stebbing, A.R.D. 1981. Hormesis-stimulation of colony growth in *Campanularia flexuosa* (Hydrozoa) by copper, cadmium and other toxicants. Aquatic Toxicol., 1: 227- 238.