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Research Article

Bioaccumulation of Some Heavy Metals (Cd, Fe, Zn, Cu) in Two Bivalvia Species (*Pinctada radiata* Leach, 1814 and *Brachidontes pharaonis* Fischer, 1870)

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Abstract: Bioaccumulation of some heavy metals (Cd, Fe, Zn and Cu) in fresh parts of 2 bivalvia species (*Pinctada radiata* Leach, 1814 and *Brachidontes pharaonis* Fischer, 1870) was examined in samples collected between May, 1999, and April, 2000, in Akkuyu Bay (İçel, Turkey).

Heavy metal contents in soft bodies were measured by an atomic absorption spectrophometer.

The means of the amounts of heavy metals with standard errors were estimated as follows: 0.0605 ± 0.00467 μgg^{-1} Cd, 2.8227 ± 0.24486 μgg^{-1} Fe, 0.2979 ± 0.02368 μgg^{-1} Zn, and 0.0355 ± 0.00303 μgg^{-1} Cu (wet weight) for *B. pharaonis*, but for *P. radiata* the means were 0.0058 ± 0.00034 μgg^{-1} Cd, 0.3682 ± 0.04252 μgg^{-1} Fe, 0.1579 ± 0.00628 μgg^{-1} Zn, and 0.0027 ± 0.00018 μgg^{-1} Cu. In a comparison of the means, the order of magnitude will be Fe, Zn, Cd and Cu for *B. pharaonis*, and Fe, Zn, Cu and Cd for *P. radiata* these results were below Turkish legal standards. Therefore, we may conclude that there is no heavy metal pollution in Akkuyu Bay.

Key Words: Bivalvia, *Pinctada radiata*, *Brachidontes pharaonis*, heavy metal

İki Bivalvia Türünde (*Pinctada radiata* Leach,1814 ve *Brachidontes pharaonis* Fischer, 1870) Bazı Ağır Metal (Cd, Fe, Zn, Cu) Birikimlerinin Araştırılması

Özet: Çalışmada (Mayıs 1999-Nisan 2000), Akkuyu Koyu'ndan (İçel-Türkiye) toplanan çift kabuklu yumuşakçalardan, *Pinctada radiata* Leach, 1814 ve *Brachidontes pharaonis* Fischer, 1870'in yumuşak dokularında Cd, Fe, Zn ve Cu birikimi araştırılmıştır.

Ağır metal içerikleri, Perkin-Elmer 2380 Model Atomik Absorbsiyon Spektrofotometresi ile ölçülmüştür.

Ağır metal birikim ortalamaları ve standart hatalar *B. pharaonis*'te 0,0605 ± 0,00467 μgg^{-1} Cd, 2,8227 ± 0,24486 μgg^{-1} Fe, 0,2979 ± 0,02368 μgg^{-1} Zn, 0,0355 ± 0,00303 μgg^{-1} Cu; *P. radiata'da* ise 0,0058 ± 0,00034 μgg^{-1} Cd, 0,3682 ± 0,04252 μgg^{-1} Fe, 0,1579 ± 0,00628 μgg^{-1} Zn, 0,0027 ± 0,00018 μgg^{-1} Cu (yaş ağırlık) olarak bulunmuştur. Buna göre, ağır metaller *B. pharaonis*'te Fe>Zn>Cd>Cu, *P. radiata*'da ise Fe>Zn>Cu>Cd şeklinde sıralanmıştır. Saptanan birikim miktarları, Türk standartlarının çok altında olduğundan, Akkuyu Koyu'nda ağır metal kirliliğinin olmadığı sonucunu çıkarmak mümkündür.

Anahtar Sözcükler: Bivalvia, *Pinctada radiata*, *Brachidontes pharaonis*, ağır metal

Introduction

Many heavy metals occur naturally in marine environments. Some of them are described as pollutants when in sufficient amounts to produce deleterious effects on some features of the ecological system. Living organisms can be used as more efficient monitors of environmental contamination. Some of them, such as bivalve molluscs, are well known for their biological features of concentrating heavy metals and other substances in their tissues. For example, oysters and mussels can accumulate Cd in their tissues at levels up to 100,000 times higher than the levels observed in the water in which they live (1).

High concentrations of trace metals have been detected in several species of marine bivalves in many parts of the world (2).

These organisms accumulate most of the contaminants at much higher levels than those found in the water column, and they are representative of the pollution of an area, for which reason they permit the

quality of coastal waters to be monitored (3). There have been several articles on heavy metal contents of whole soft bodies of marine bivalve populations (4-9).

For the marine monitoring studies of sedentary organisms, widely distributed geographical studies capable of accumulating metals, so as to reflect the environmental conditions, are employed (10). Bivalvia species especially have been used as biological indicator organisms to monitor marine environmental pollution by heavy metals and chemicals due to their own properties of inhabitation (11-13).

Heavy metal concentrations in soft bodies have been discussed in all of the investigations concerned. For example, according to Gundacker (14), zebra mussels accumulate high amounts of potentially toxic heavy metals and are widely used as a bio-monitoring organism.

On the other hand, as a result of rapidly developing industries, especially in bays having poor current conditions, there is a significant increase in heavy metal pollution (15).

In this study, heavy metal (Cd, Fe, Zn and Cu) contents in littoral sessile species of Bivalvia (*Pinctada radiata* Leach, 1814 and *Brachidontes pharaonis* Fischer, 1870) were investigated. Organisms were collected from Akkuyu Bay (Figure 1), where a nuclear power station will be built in the future.

Pinctada radiata is a member of the family Pteriidae. One member of this family is the pearl oysters. They are 50 to 106 mm in length and are an Indo-Pacific species. First recorded from Cyprus in 1899 the species has spread in the Eastern Mediterranean. They live attached by their byssus to rocks or other hard substrates. They are fouling organisms (16). Systematics of *P. radiata* are given below (17):

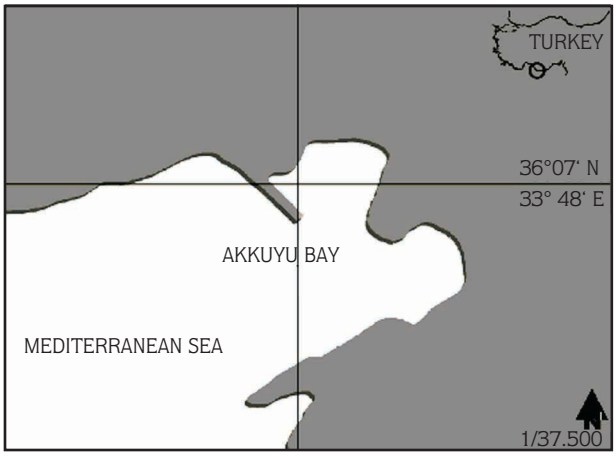

Figure 1. Akkuyu Bay / İçel-Turkey.

Phyllum: Mollusca

Classis: Bivalvia Linneaus, 1758

Subclassis: Pteromorphia Beurlen, 1944

Ordo: Pterioida Newell, 1965

Subordo: Pteriina Newell, 1965

Super Familia: Pteriodea Gray J.E., 1847

Familia: Pteriidae Gray J.E., 1847 (1828)

Genus: Pinctada Roeding, 1798

Species: *Pinctada radiata* (Leach, 1814) [Avicula]

Brachidontes pharaonis is a member of the family Mytilidae, one of whose members is the edible mussel, which is 20 to 30 mm in length. The family has the best intertidal bivalves with a worldwide distribution. A Lessepsian species that migrated to the Mediterranean at the end of the 1960s, it is now a common species in the Mediterranean. It lives in shallow water attached by its byssus to rocks or rubble (16). The systematic of *B. pharaonis* is given below (17):

Phyllum: Mollusca

Class: Bivalvia Linneaus, 1758

Subclassis: Pteromorphia Beurlen, 1944

Ordo: Mytiloida Ferussac, 1822

Super Familia: Mytiloidea Rafinesque, 1815

Familia: Mytilidae Rafinesque, 1815

Subfamilia: Mytilinae Rafinesque, 1815

Genus: Brachidontes Swainson, 1840

Species: *Brachidontes pharaonis* (Fischer P., 1870)[Mytilus]

Materials and Methods

Organisms were collected by hand by snorkelling, immediately stored in an insulated box containing ice cubes and transferred to deep freeze (-20 ^{0}C) in the laboratory until the time for analysis.

Samples were collected between May, 1999, and April, 2000, in Akkuyu Bay (İçel, Turkey).

The shell length (cm) and the shell width (cm) were measured using compasses, but the fresh weight (g) of samples was determined with a balance in the laboratory.

Approximately 1 g of freeze-dried sample was placed in a Teflon reactor. After the addition of 2 ml of perchloric acid and 2 ml of nitric acid, the samples were digested in a microwave oven. When the samples were cold, the volume was adjusted to 25 ml with distilled water, and they were then transferred to a glass flask. Cd, Fe, Zn and Cu were determined using atomic absorption spectrophotometry (Perkin Elmer 2380) (18).

The metal content was represented as $\mu g g^{-1}$ on a wet weight basis.

The means ($\bar{X}$) with standard errors ($S\bar{x}$) and 95% confidence limits for the width, length and weight of each species were estimated. The same statistical methods were employed for heavy metal accumulation, including t-test statistics (19).

Results

Means ($\bar{X}$) with standard errors ($S\bar{x}$), t-test results and 95% confidence limits for the width, length, weight and amount of heavy metals for both species are given in Table 1 and in Table 2, respectively. However, the 95% confidence limits of the heavy metal accumulation in both species are presented in Figure 2.

Discussion

On examination of Table 2, Fe has the highest mean for both species, but Cu for *B. pharaonis* and Cd for *P. radiata* have the lowest means.

The means of all heavy metal accumulation for *B. pharaonis* and *P. radiata* are statistically significant ($P < 0.01$). Therefore, it may be concluded that these 2 species can be used as indicator species for heavy metal accumulation studies (1,12).

Accumulations found in *B. pharaonis* were higher than those in *P. radiata*. Boyden (20) reported that there were grated accumulations in small organisms than in others.

If we compare the means, the order of magnitude will be Fe, Zn, Cd and Cu for *B. pharaonis* and Fe, Zn, Cu and Cd for *P. radiata*, Fe and Zn thus occupy similar positions in both species. Cd and Cu occupy different positions, however, in the 2 species. Consequently, Cu accumulation was higher in the oyster *P. radiata* than in the mussel *B. pharaonis.* Similarly, Ikuta (21) reported that, Cu accumulation is generally higher in the oyster than in the other bivalvia species.

The means of heavy metal concentrations were beneath Turkish legal standards, which are 1.0 $mgkg^{-1}$ for Cd, 20.0 $mgkg^{-1}$ for Cu and 50.0 $mgkg^{-1}$ for Zn (wet weight) in bivalve mollusks (22). Therefore, we may conclude that there is no heavy metal pollution in Akkuyu Bay.

Table 1. Means ($\bar{X}$) with standard errors ($S\bar{x}$) and 95% confidence limits of the weight, length and width for *B. pharaonis* and *P. radiata*.

Species		($\bar{X}$) ± ($S\bar{x}$) ($\mu g g^{-1}$)	95% Confidence Limits ($\mu g g^{-1}$)	
			Lower	Upper
Brachidontes pharaonis	Weight (g)	0.022 ± 0.004	0.015	0.029
	Length (cm)	1.906 ± 0.024	1.858	1.954
	Width (cm)	1.060 ± 0.015	1.030	1.090
Pinctada radiata	Weight (g)	0.229 ± 0.016	0.198	0.261
	Length (cm)	3.516 ± 0.070	3.375	3.656
	Width (cm)	3.654 ± 0.068	3.517	3.791

Table 2. Means ($\bar{X}$) with standard errors ($S\bar{x}$), 95% confidence limits and the results of the t-test for heavy metals accumulation in *B. pharaonis* and *P. radiata*.

Species	Heavy Metals	($\bar{X}$) ± ($S\bar{x}$) ($\mu g g^{-1}$)	95% Confidence Limits ($\mu g g^{-1}$)	
			Lower	Upper
Brachidontes pharaonis	Zn	0.2979** ± 0.02368	0.250	0.345
	Cu	0.0355** ± 0.00303	0.029	0.042
	Cd	0.0605** ± 0.00467	0.051	0.069
	Fe	2.8227** ± 0.24486	2.331	3.315
Pinctada radiata	Zn	0.1579** ± 0.00628	0.145	0.171
	Cu	0.0027** ± 0.00018	0.002	0.003
	Cd	0.0058** ± 0.00034	0.005	0.006
	Fe	0.3682** ± 0.04252	0.282	0.454

**P < 0.01: Significant (t-test)

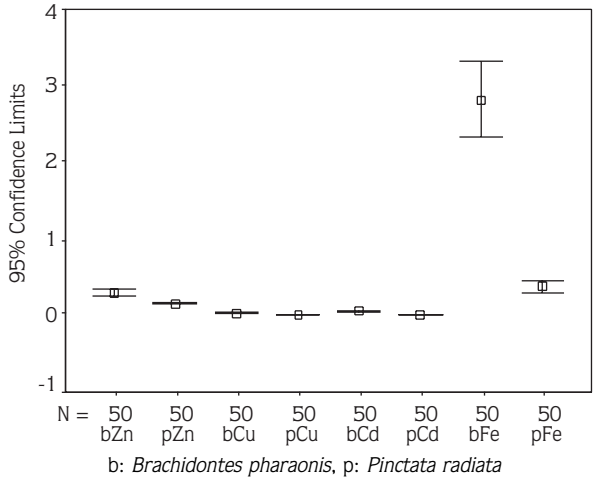

Figure 2. 95% Confidence limits of the means of heavy metal accumulations for *B. pharaonis* and *P. radiata*.

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